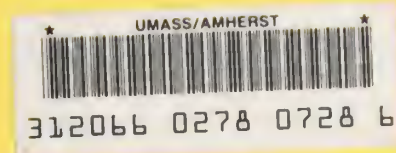


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CTPS TECHNICAL REPORT

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HIGHLAND AVENUE/ NEEDHAM STREET CORRIDOR TRAFFIC STUDY: EXISTING CONDITIONS

August 1986

CTPS TECHNICAL REPORT 56a

TITLE HIGHLAND AVENUE/NEEDHAM STREET
CORRIDOR TRAFFIC STUDY:
EXISTING CONDITIONS

AUTHOR(S) LAWRENCE H. TITTEMORE
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DATE AUGUST 1986

ABSTRACT

This study initially focused on investigating long-term solutions to the traffic problems in the Highland Avenue/Needham Street corridor. During the data-collection phase, particularly as early field surveys were being done, it became apparent that certain study-area traffic problems could be addressed without major reconstruction and prior to completion of a detailed evaluation of future conditions. This report was therefore split from the larger effort to provide information on how traffic conditions could be improved in the short-term.

Efforts subsequently focused on the identification of existing safety and capacity problems and on actions that could be implemented in the short-term at relatively low cost. Intersections and road segments were examined in detail and recommendations were developed for problem locations where traffic-management techniques could be used to significantly improve present traffic conditions.

The recommendations were made with an understanding of what kinds of actions will be required long-term to correct major traffic-operation problems, current and anticipated, in the Highland Avenue/Needham Street corridor. The future-conditions portion of the study will be presented in CTPS Technical Report 56b.

This document was prepared by **CENTRAL TRANSPORTATION PLANNING STAFF**, an interagency transportation planning staff created and directed by the Metropolitan Planning Organization, consisting of the member agencies.

Executive Office of Transportation and Construction
Massachusetts Bay Transportation Authority
Massachusetts Department of Public Works
MBTA Advisory Board
Massachusetts Port Authority
Metropolitan Area Planning Council

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— MAPC REGION
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1 INTRODUCTION

1.1 PURPOSE

The Central Transportation Planning Staff (CTPS), under the direction of the Sub-Signatory Committee (SSC) of the Boston Metropolitan Planning Organization (MPO) and at the request of the Massachusetts Department of Public Works (MDPW), has undertaken a feasibility analysis of a proposed improvement plan for the Highland Avenue/Needham Street corridor in the Town of Needham and the City of Newton. This improvement plan, the "Highland Avenue/Needham Street Corridor Consensus Plan," was developed jointly by officials of the City of Newton, the Town of Needham, and the Newton-Needham Chamber of Commerce.

The CTPS study was devised to provide an update of existing traffic conditions, identify problem areas requiring immediate attention, develop possible solutions including those described in the "Consensus Plan," and assess the long-term sufficiency of all feasible solutions.

To advise the CTPS staff during the study process, a technical advisory committee (TAC) was formed. The TAC includes members representing the two communities, area business interests, the MDPW, the Executive Office of Transportation and Construction (EOTC), and the Metropolitan Area Planning Council (MAPC). The individual TAC members include:

City of Newton

Barry Canner, Director of Planning and Development
Roy LaMotte, Traffic Engineer

Town of Needham

Calvin Cook, Planning Director
Jack Marr, Town Engineer

Newton/Needham Chamber of Commerce

John Fox, Chairman
Lewis Songer, Executive Vice President
Lewis Branzburg, Member

Massachusetts Department of Public Works

Michael Meyer, Director, BTP&D
John Gaynor, Location Engineer, BTP&D
Robert Patneaude, BTP&D/CTPS Liaison

Executive Office of Transportation and Construction
Allan McKinnon, Assistant Secretary
Robert Sloane, EOTC/CTPS Liaison

Metropolitan Area Planning Council
Edward Bates, Transportation Group Manager

Subsequent to the release of this report as a preliminary draft to the client (MDPW) in December 1985, the TAC was briefed by CTPS on the findings, conclusions, and recommendations made in the study. Following that briefing, community and Chamber of Commerce representatives met to formulate a response to those recommendations. Their response, in letter form, contained comments, reservations, and suggestions. After careful review, CTPS formally responded to each of the issues raised in that letter.

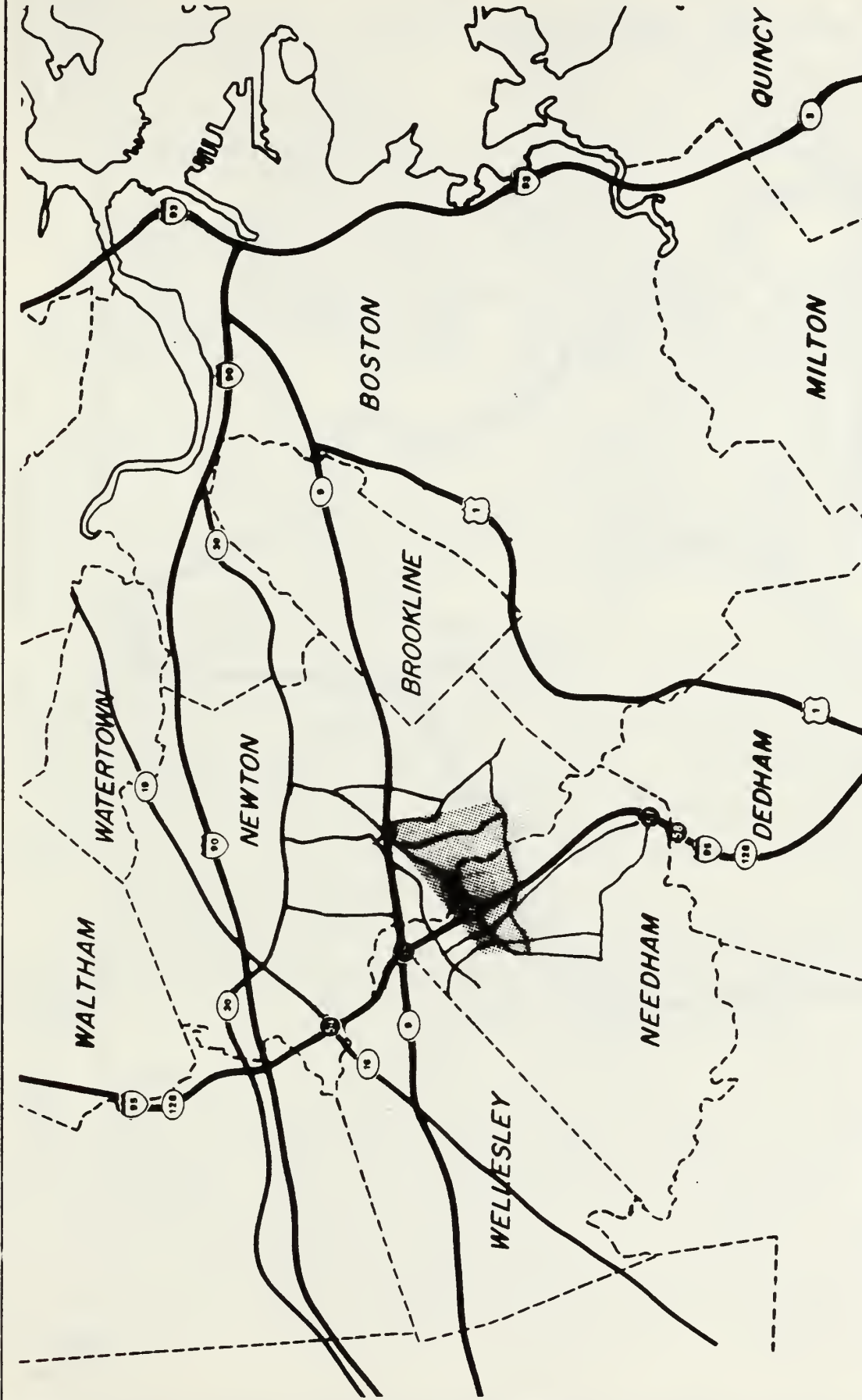
This exchange of correspondence is incorporated into this report as Appendix A. It is crucial that this correspondence be viewed as a form of "final chapter" in order to gain an understanding of the actual disposition of this report.

1.2 STUDY-AREA DEFINITION

The Highland Avenue/Needham Street study area straddles the Charles River where it forms the boundary between the municipalities of Needham and Newton. This is approximately 10 miles to the west-southwest of downtown Boston (refer to Figure 1-1).

North-south, limited-access highway service is available on Route 128 (via Interchange 56), which serves, in part, as an intermediate link of Interstate 95. Approximately four miles to the north, Route 128 intersects I-90 (the Massachusetts Turnpike). Interstate 90, operated by the Massachusetts Turnpike Authority, is the only limited-access east-west facility in the Commonwealth. Alternative east-west service is provided by Route 9 (Boylston Street), a median-divided, four-lane facility which parallels the northern border of the study area and crosses Route 128 at a grade-separated interchange approximately one mile north of Interchange 56.

The study area is bordered on the west by Greendale Avenue and Webster Street in Needham (refer to Figure 1-2). The northern border follows the former Penn Central railroad tracks from the Webster Street crossing in the west to the Route 9/Winchester Street interchange. From this point the eastern boundary follows a line to the south essentially parallel to Winchester Street. The southern boundary loops around the Route 128 Office Park in Newton and parallels Kendrick Street in Needham.



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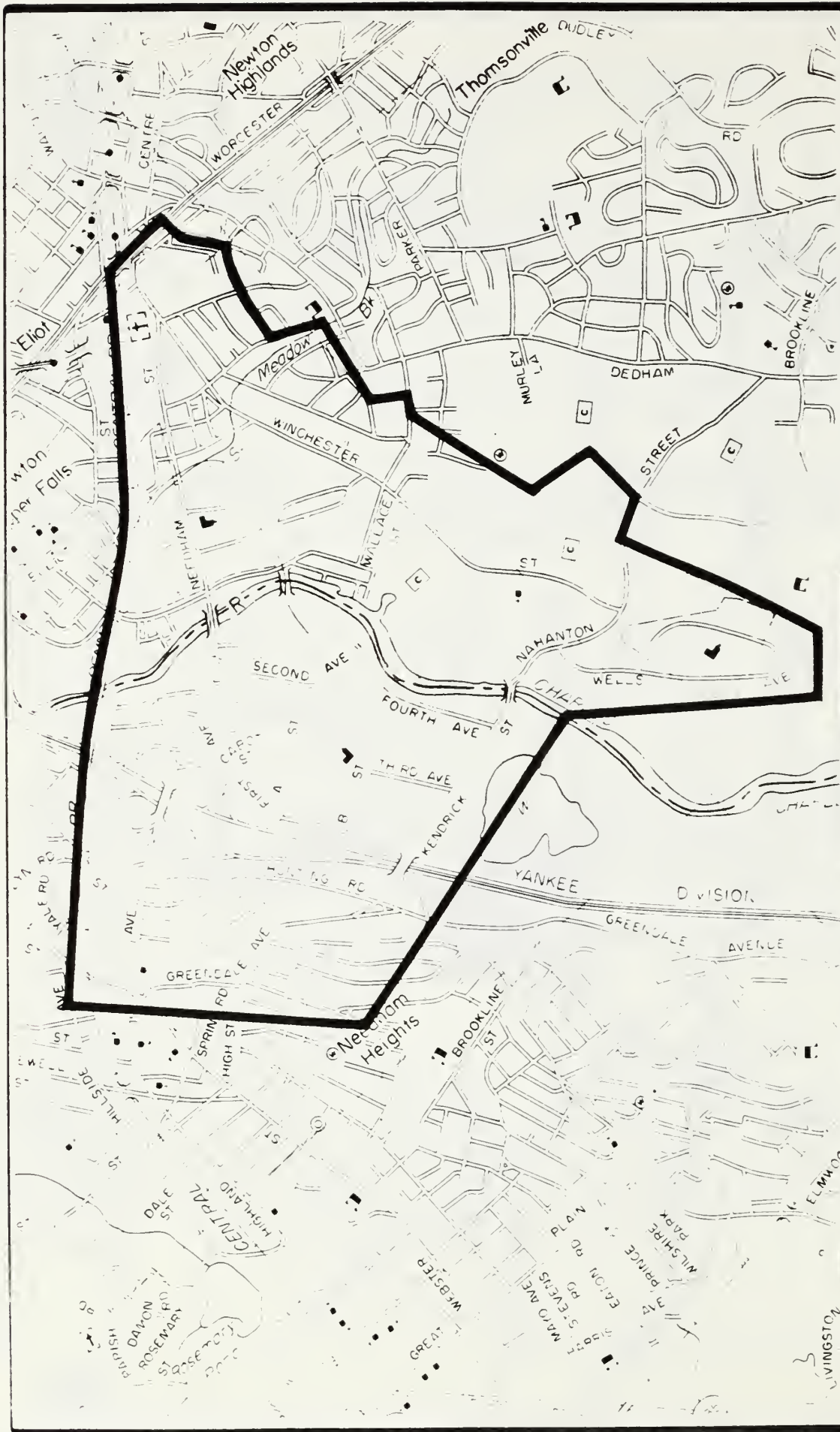
FIGURE

1-1

HIGHLAND AVENUE/NEEDHAM STREET STUDY AREA
OVERVIEW

1 2
Miles

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CTPS

FIGURE

1-2

STUDY-AREA BOUNDARY MAP



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2 LAND USE

2.1 INTRODUCTION

The Metropolitan Area Planning Council (MAPC) performed the land-use inventory and analysis for this study. A detailed examination of the area is important in light of the burgeoning growth and development pressures occurring there.

The inventory is a compilation of land-use data from Needham and Newton assessors' records of the square footage of buildings for each of three generalized land-use types: manufacturing, office, and retail. In addition, residential land-use data have been collected as it relates to the number of housing units--and the units per acre for high concentrations of homes--in the study area. These data were used for trip-generation purposes.

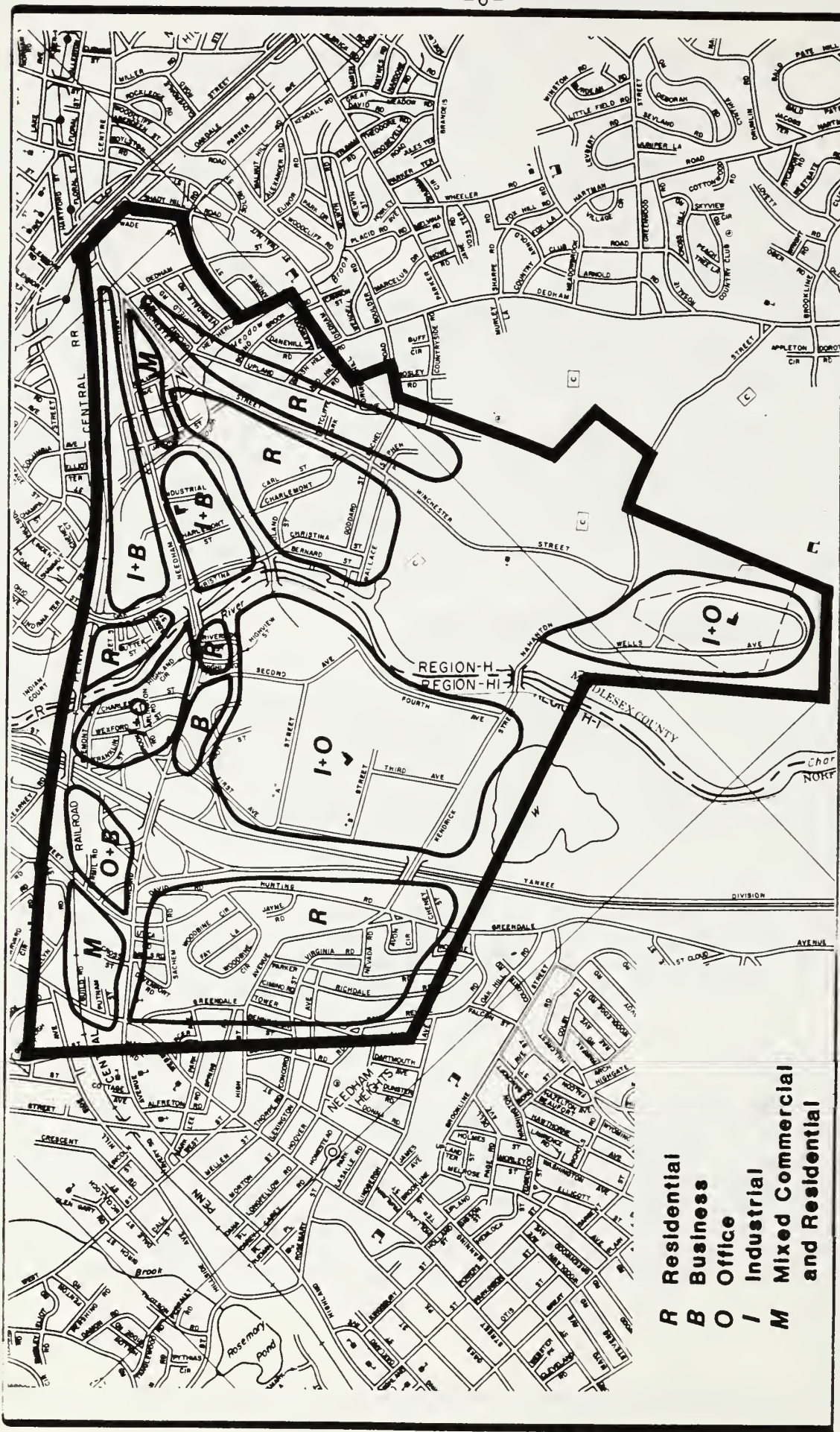
2.2 OVERVIEW OF EXISTING CONDITIONS

Figure 2-1 depicts the general land uses in the study area as of the base year of 1984. Land use in the study area ranges from residential around the periphery to more intensive uses such as retail, office, and industrial along major transportation thoroughfares. Vacant land, for the most part, is not available for development purposes. Instead, new development in the area is occurring through the redevelopment of presently underutilized parcels for more intensive uses for which there is currently more of a demand.

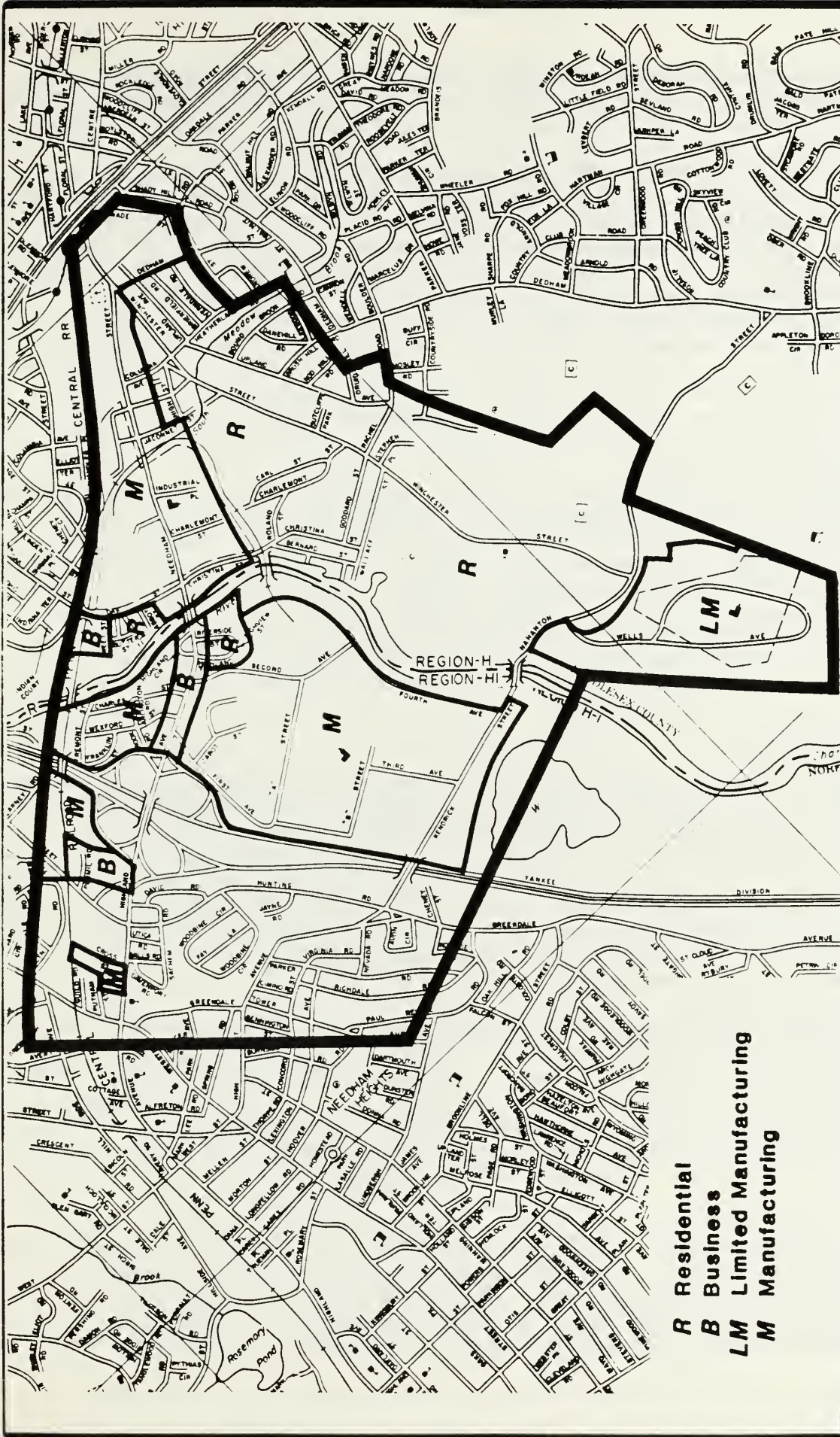
The mix of land uses is not compatible in some areas, with the intensity of uses varying markedly, thereby exacerbating the problems along the Highland Avenue/Needham Street corridor. Figure 2-2 presents generalized zoning districts for the study area.

2.2.1 Needham

Needham's portion of the study area is bisected by Route 128, which serves as an effective buffer between highly divergent land-use types. West of the Route 128 right-of-way, the land use south of Highland Avenue is virtually all residential to Webster Street and Tower Avenue on the west. As this area is zoned for single residences and is an established residential district, no commercial or industrial intrusions are to be anticipated; there is some office, retail, and light industrial development to the



CTPS	FIGURE 2-1
GENERAL LAND-USE MAP	
Highland Avenue/ Needham Street Traffic Analysis	Technical Report 56a August 1986



CTPS	FIGURE 2-2
GENERAL ZONING-DISTRICT MAP	
Highland Avenue/ Needham Street Traffic Analysis	Technical Report 56a August 1986

north of Highland Avenue, which becomes more intensive as one approaches Route 128 from the west. The parcel of land presently occupied by Muzi Ford, a large car dealership, anchors this area.

East of the Route 128 right-of-way, the existing land use is almost exclusively non-residential in character. Here, Highland Avenue is bordered by more local, service-oriented facilities, with the larger, regional businesses occupying the "off-Highland" sites, culminating in the New England Industrial Center, located on the southern side of the street. As the industrial park is zoned for manufacturing, which is an inclusive zoning district in Needham, some business uses as well as most office and manufacturing uses are allowed by right or special permit. The strip zoned for business that borders Highland Avenue allows single-family residences as of right and manufacturing uses by special permit.

Land use becomes less intensive near the Charles River/Newton line, with smaller businesses and residences abutting Highland Avenue. The residential district at Highland Terrace/Riverside Street, located to the southern side of Highland Avenue, stands as a bastion against development and is reflective of a time when Needham was not confronted with heavy demands for, and pressure from, development. Unlike those residential units across the street on the northern side of Highland Avenue, this area is likely to remain unchanged in the near term.

2.2.2 Newton

Across the Charles River, more intensive land uses again prevail, with a mix of commercial and light industrial uses bordering Needham Street. Strip development characterizes the corridor between the Charles River and Winchester Street to the east, with a myriad assortment of retailers and the sprawling, somewhat ill-defined Newton Industrial Center (NIC) spilling over each side of Needham Street and filtering down Tower Road on the northern side and Industrial Place and Charlemont Street on the southern side of Needham Street.

The NIC is actually a number of small industrial parks situated on these side streets. They are located on one-way or dead-end roads, which protects adjacent residential areas. The industrial buildings are, for the most part, low-rise, older structures with limited setbacks--or no setbacks--and off-street parking. They are generally "orphans," associated with the Needham Street area's former role as an industrial center.

The Needham Street corridor is undergoing a complex infill scenario accompanied by changes both in scale of development and in predominant use. Interspersed among the industrial uses in the NIC are newer retail and office complexes, including the 60,000-square-foot Marshall's Shopping Plaza. This scenario occurs as a result of zoning areas for lighter industrial or

heavy commercial uses, for which the ordinance provisions are more flexible than for typical retail commercial zones.

The zoning in the Needham Street corridor (approximately 200 feet to either side of the street) is for manufacturing. This zoning classification in Newton is at present essentially an "open door" zone. Such zoning can act as a conduit for related activities to come in and cannibalize parcels which are ripe for conversion to uses for which there is more market demand. The office intrusions along Needham Street that are already taking place have led to speculation as to what will become of some of the larger industrial parcels that border Needham Street in the near future.

There is a large residential area separating the Needham Street corridor from the Wells Avenue at Route 128 Office Park to the south. This includes a thickly settled area of single-family homes nearer to the corridor and more open land, containing the Jewish Community Campus and the Charles River Country Club, nearer to the office park. These latter parcels, because of their proximity to Wells Avenue, are prime sites for more intensive uses, assuming that demand remains strong in the future.

The Wells Avenue at Route 128 Office Park comprises mostly low-rise, expansive buildings in a campus-like environment with sufficient off-street parking. It is zoned "limited manufacturing," which allows certain commercial, office, and industrial uses by right. Although a range of uses is permitted, the large number of office buildings reflects the demand for office space in the area. With a ceiling cap on office development at 1,200,000 square feet, which has nearly been reached, Newton will experience additional pressure from outside to allow more office developments in this area.

2.3 ANALYSIS OF DATA

Data has been compiled on the current land uses in the study area in terms of housing units and square footage of office, retail, and manufacturing buildings. This information was gathered from the Needham and Newton assessors' offices and from field visits to each community, as well as in conversations with local planners and officials.

The square footage of existing non-residential buildings was classified, using assessors' records, by predominant land-use type for trip-generation purposes. When available, the specific type of business was identified.

Manufacturing is the principal land use in the Needham section, with 2.5 million square feet of space, followed by office with 875,000 square feet and retail with 230,000. The New England Industrial Center is clearly in evidence in these numbers.

In Newton, as in Needham, manufacturing is the principal land use, with 1.5 million square feet of space, followed by office with 1.2 million square feet and retail with 300,000. The Newton Industrial Center accounts for most of the manufacturing total, while the more recent growth in office development can be seen in the Wells Avenue at Route 128 Office Park, which accounts for two thirds of the office total. Retail uses are confined to the Needham Street corridor.

The largest number of residential units in the study area can be found west of Route 128 in Needham, an area characterized by single-family homes on larger lots, with vacant land virtually nonexistent. The Winchester Street area of Newton has a large concentration of homes on smaller lots, with considerable open space. Finally, the cluster of homes in Needham east of Second Avenue merits inclusion, primarily because of its location in the corridor and the traffic impacts it generates and receives.

2.4 SUBAREA CHARACTERISTICS

The study area has been divided into a number of subareas, for ease in interpretation as well as a finer breakdown of data on residential, office, retail, and manufacturing uses. There are five subareas in Needham and three in Newton, as shown in Figure 2-3; land-use statistics for each are presented in Table 2-1.

2.4.1 Needham

Needham has been divided into Subarea A (north of Highland Avenue from Webster Street to Route 128), Subarea B (south of Highland Avenue from the study area's western boundary to Route 128), Subarea C (north of Highland Avenue from Route 128 to the Newton line), Subarea D (south of Highland Avenue from Route 128 to the Newton line by including only the swath of land abutting Highland Avenue and the residential area of Highland Terrace), and Subarea E (south of Subarea D from Route 128 to the Newton line, including almost all of the New England Industrial Center).

Subarea A is characterized by a mix of land uses which generally follow the pattern of industrial nearest the railroad and highway, office and retail along Highland Avenue, and residential along the side streets. Muzi Ford dominates the area, because of its visibility from the highway, and acts as a cornerstone for the industrial uses to its north and the newer retail and office uses trickling down Highland Avenue. It acts, in effect, as the gateway to Needham and, with the New England Industrial Center, is what most people who travel Route 128 have come to visually associate with Needham.

Subarea B, with the exception of a single office building, is an established residential area. Single-family homes predominate, reinforcing Needham's image as a residential suburb.

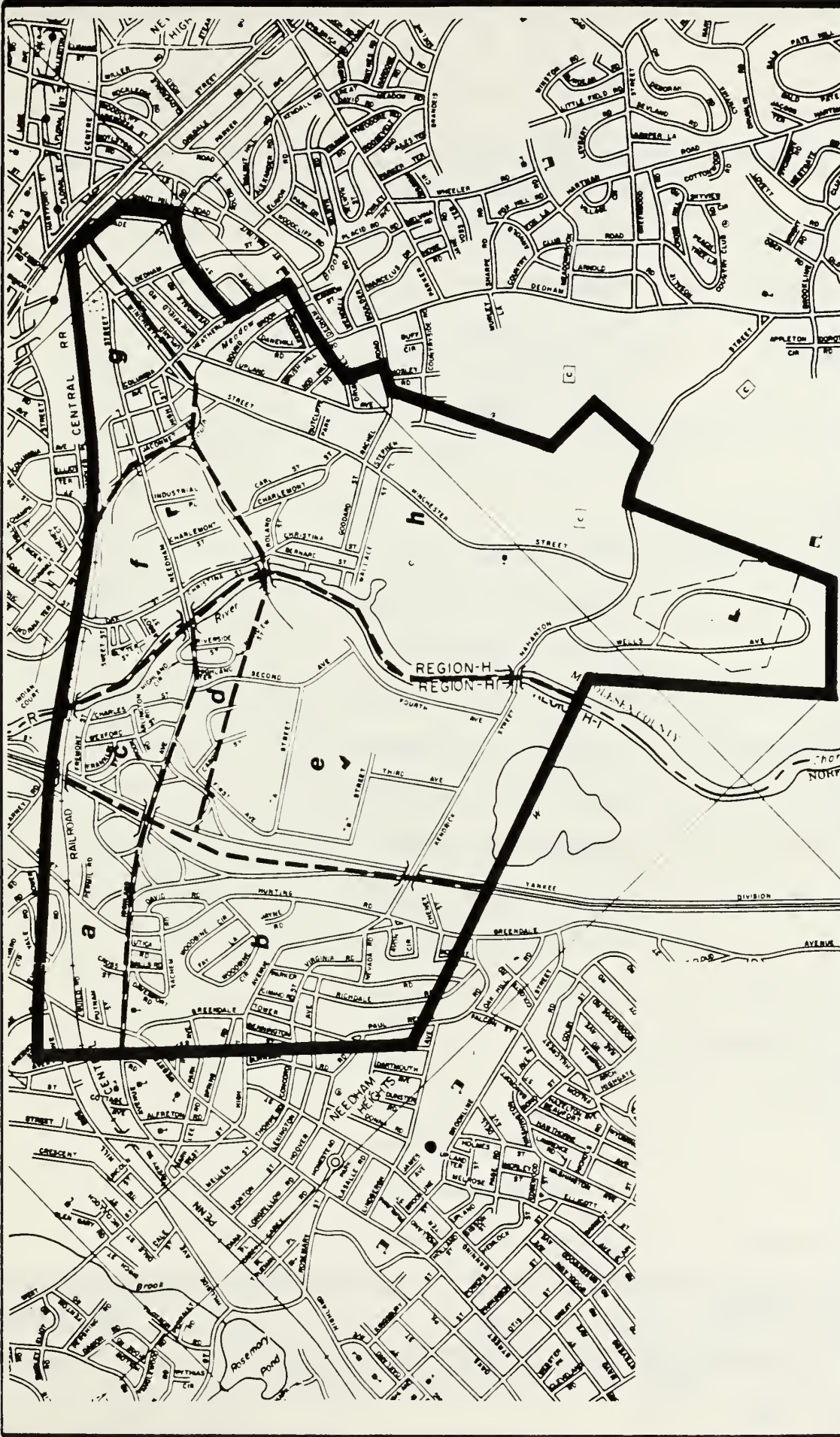
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FIGURE

2-3

LAND-USE SUBAREA BOUNDARY MAP

Highland Avenue/
Needham Street
Traffic Analysis
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Subarea A (Assessor's maps 70, 76, 77, 78, 79, 94)

Residential	58 units on 25.7 acres = 2.3 units/acre
Office	148,832 square feet
Retail	40,142 square feet
Manufacturing	28,560 square feet

Subarea B (Assessor's maps 57, 58, 59, 60, 64, 65, 66, 67, 68, 71, 72)

Residential	457 units on 157.9 acres = 2.9 units/acre
Office	5,992 square feet
Retail	-
Manufacturing	-

Subarea C (Assessor's maps 74, 75)

Residential	12 units on 2.3 acres = 5.2 units/acre
Office	168,521 square feet
Retail	97,645 square feet
Manufacturing	221,809 square feet

Subarea D (Assessor's maps 73, part of 300)

Residential	43 units on 8 acres = 5.4 units/acre
Office	26,010 square feet
Retail	49,086 square feet
Manufacturing	52,880 square feet

Subarea E (Assessor's map 300)

Residential	-
Office	525,321 square feet
Retail	42,103 square feet
Manufacturing	2,112,348 square feet

Highland Avenue/
Needham Street
Traffic Analysis

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HOUSING UNITS AND
NON-RESIDENTIAL BUILDING SPACE
NEEDHAM SUBAREAS

CTPS

TABLE

2-1a

Subarea F (Assessor's maps 51/28/5-8G, 51/49/6, 83/28/77-84, 83/30/9-12, 83/31/25&26)

Residential	77 units
Office	98,962 square feet
Retail	186,469 square feet
Manufacturing	985,221 square feet

Subarea G (Assessor's maps 51/28/11-30, 83/3/44-53, 83/11/14-23, 83/12/1-8, 83/13/4-13, 83/28/1+2)

Residential	50 units
Office	299,091 square feet
Retail	111,061 square feet
Manufacturing	191,747 square feet

Subarea H (Assessor's maps 83/36/4, 84/34/2A-2U, 84/341/1-8)

Residential	419 units on 32.5 acres = 12.9 units/acre
Office	839,913 square feet
Retail	5,753 square feet
Manufacturing	274,747 square feet

Highland Avenue/
Needham Street
Traffic Analysis

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August 1986

HOUSING UNITS AND
NON-RESIDENTIAL BUILDING SPACE
NEWTON SUBAREAS

CTPS

TABLE

2-1b

Subarea C is primarily a non-residential area characterized by industrial uses closer to the railroad and Route 128, with office and retail uses along or just behind Highland Avenue; a few residences remain, huddled around Highland Circle. Because of the lack of through streets and the historical industrial development of the area, the existing uses are crowded together, with no thought to setbacks or landscaping. This, as well as the small size of the parcels, acts as a hindrance to major redevelopment of the subarea.

Subarea D is also characterized by a mix of land uses, with residential anchoring the Newton border, retail and office abutting Highland Avenue, and manufacturing leading into the New England Industrial Center. This is where Second Avenue, the principal ingress/egress of the industrial park, intersects with Highland Avenue.

Subarea E is the New England Industrial Center (NEIC), predominantly industry-oriented but with a sizable office segment as well. It is this development which has made industry of growing significance to the economy of Needham. The NEIC is contained by the Charles River Reservation to the south, the Charles River to the east, and Route 128 to the west. To the north, however, Highland Avenue interrupts the natural northward extension of the industrial area to the railroad.

The automobile orientation of Highland Avenue has lent itself to the development of the corridor first as a commercial strip, and now as a mixed commercial and office strip. Subarea C's smaller service establishments north of Highland Avenue are presently experiencing encroachment from office buildings, as evidenced by the Babcock-AAA building. These factors have contributed to the present state of flux, which will no doubt continue until market pressures ease. The NEIC is characterized by a large number of manufacturing and distribution centers. Minimal building setbacks and limited off-street parking, as well as the street layout within the Center, combine to form a visual morass.

2.4.2 Newton

Newton has been divided into Subarea F (both sides of Needham Street between the railroad rights-of-way to the north and south, from the Charles River to the railroad right-of way west of Jaconnet Street), Subarea G (both sides of Needham Street between the railroad right-of-way to the north and Winchester Street to the south, from the railroad right-of-way west of Jaconnet Street to Curtis Street on the east), and Subarea H (the Winchester Street area south of the railroad right-of-way, including the Wells Avenue at Route 128 Office Park, west to the Charles River).

Subarea F contains the Newton Industrial Center and the newer Marshall's Shopping Plaza. Although this area is heavily manufacturing-oriented, the last few years have seen more office and retail growth, resulting in a link between the commercial strip in Needham and that in Subarea G to the east. One-way and dead-end streets off Needham Street give a feeling of congestion and crowding to the Newton Industrial Center. The residential area off of Oak Street is hemmed in by nonresidential uses, the railroad, and the Charles River.

Subarea G contains a more balanced mix of office, retail, and manufacturing uses than Subarea F. Without a confining railroad right-of-way to the south, this area has been able to diversify, and is characterized by a number of office uses, followed by manufacturing and retail, respectively. An ill-defined, congested residential area serves as a buffer for the residences south of Winchester Street, in effect taking the place of the railroad right-of-way buffer to the west.

Subarea H is effectively two districts: a large residential area, and the Wells Avenue at Route 128 Office Park. The residential area has more houses per acre than the one in Needham, but is also characterized by areas of open space. The office park, against the Charles River/Needham border, is a well-planned, sprawling office and warehouse area providing generous setbacks and off-street parking. It presents a pleasant work environment and an attractive location, and has attained nearly 100-percent occupancy.

3 BACKGROUND

3.1 PREVIOUS CTPS WORK

The initial and principal work in which CTPS has previously addressed traffic problems along the Highland Avenue/Needham Street corridor is documented in the Highland Avenue/Needham Street Reconnaissance Report, published in February 1980. Intended as a broad-scope assessment of the reasons for traffic congestion in the corridor, the report outlined three primary causes of local traffic problems:

- o Significant increases in commercial development without commensurate increases in the capacity of the existing roadway, particularly Highland Avenue Bridge
- o Common arrival and departure times for most work trips in the area
- o A relatively high percentage of single-occupant vehicle trips in the corridor

To address these issues, the report recommended the consideration of a series of steps to be implemented as a comprehensive program:

- o Detailed evaluation of a roadway-widening program from Second Avenue in Needham to Winchester Street in Newton, including assessment of need for additional vehicle control at Winchester Street and Dedham Street and at Oak Street and Christina Street
- o Promotion of an employer-based program for variable work hours and carpool matching
- o Examination of expanded MBTA regular-route and express bus service in the corridor
- o Consideration by the municipalities of Needham and Newton of the institution of site-plan review requirements for all future development within the corridor

The reconnaissance report led to further discussion among community leaders in Needham and Newton which culminated in endorsement of the "Highland Avenue-Needham Street Corridor Consensus Plan."

In addition to the reconnaissance report, pertinent CTPS work includes Newton-Needham RACMs Project: Final Report (CTPS Technical Report 29b, February 1983), a study of an employer-based ridesharing program designed to examine the effects of car-pool promotion on peak-hour travel and air quality. The program focused on the New England Industrial Center (NEIC), which borders Route 128 and Highland Avenue in Needham, and was initiated in the spring of 1982. Participation proved to be of limited interest to employers and employees working in the area.

A number of factors, including the economic climate, the dispersion of work-trip origins, and the diversity of the area's industry, contributed to the apparent lack of interest in the carpool program. The resultant low-level participation in the program produced no detectable impact on peak-hour traffic volumes or auto emissions. The report points out, however, that the factors influencing commuter choices may change. Suggesting a future scenario of limited parking supply, gasoline shortages, and higher gasoline prices, the report concludes that ridesharing could become significantly more attractive to area commuters and could help to improve peak-hour traffic conditions.

3.2 OTHER PREVIOUS WORK

3.2.1 TOPICS Plans

Traffic operations in the communities of Needham and Newton were comprehensively reviewed in 1972 as part of the Areawide TOPICS planning effort of the Massachusetts Department of Public Works. In the city of Newton, TOPICS identified the "Centre Street/Winchester Street Area" between Walnut Street and Needham Street as containing a series of high-accident locations. At the intersections of Walnut Street/Centre Street, Route 9 ramps at Centre Street and Winchester Street, and Winchester Street/Needham Street, signal installations and geometric revisions were recommended. To date, TOPICS-recommended improvements on this segment have been completed only at the Walnut Street/Centre Street intersection.

The Newton TOPICS plan also cites traffic problems along Needham Street, which it ascribes to the intensity of abutting commercial and industrial activity. Particular problems are noted in the vicinity of the Highland Avenue Bridge, where the narrowed surface is thought to restrict traffic flow between Needham and Newton. Reconstruction of a widened Needham Street and bridge is recommended in conjunction with additional access controls on Needham Street, these measures to be implemented as a coordinated effort.

At the time the Needham TOPICS plans were being written (1971 and 1972), the Wells Avenue at Route 128 Office Park was in the development stage and public hearings were being held by the Massachusetts Department of Public Works (MDPW) to discuss design plans for improvements along Highland Avenue from Route 128 to

Second Avenue. The improvements under design were to address accident problems at four intersections on Highland Avenue:

- o First Avenue
- o Wexford Street
- o Charles Street
- o Second Avenue

At the time, First Avenue traffic was controlled by a semi-actuated signal, and operations at Wexford Street, Charles Street and Second Avenue were uncontrolled. The MDPW designs called for new traffic signals at each location. At the Wexford Street and Charles Street intersections, TOPICS recommended consideration of a traffic signal coordinated with the First Avenue and Second Avenue controllers. Citing significant levels of traffic apparently generated by the area's industrial activities, circulation adjustments and new pavement markings were also recommended for consideration.

To the south of the NEIC on Kendrick Street, the Wells Avenue at Route 128 Office Park was expected to generate significant volumes of additional traffic. Peak-hour conditions were, therefore, expected to deteriorate at the intersections of Third Avenue and Fourth Avenue. To maintain acceptable peak-hour conditions for the foreseeable future, TOPICS recommended consideration of installing fully actuated signals at both Third Avenue and Fourth Avenue, with improved channelization and pavement markings.

In response to expectations of continued expansion of industrial and commercial activities in the Highland Avenue/Route 128 area, three additional recommendations were made in the Needham TOPICS plan:

- o Development of an improved route to Highland Avenue along Fourth Avenue or Second Avenue, to minimize the utilization of residential streets for commuter travel.
- o Commitment by the community to the development of a traffic plan that would provide new access roads and circulation controls on the north side of Highland Avenue between Gould and Webster streets. Pressure for more intensive commercial use of the area was advancing and threatened to disrupt traffic operations in the area.
- o Construction of a new off-ramp from Route 128, in order to reduce the conflict between exiting traffic from Route 128 northbound and eastbound traffic on Highland Avenue. The new off-ramp would begin north of Kendrick Street, be aligned between and parallel to First Avenue and Route 128, and connect with the existing southeast-quadrant ramps. The new ramp would have a direct connection to First Avenue at A

Street, to serve the industrial park. In conjunction with this proposal a ramp to move southbound traffic onto Route 128 from the industrial park (as well as other generators) was suggested. Such a ramp connection was physically feasible south of Kendrick Street but significant grade and right-of-way adjustments and a possible widening of the Kendrick Street underpass on Route 128 would require further consideration.

3.2.2 Transportation-Impact Study of Affiliated Jewish Community Campus

In March 1979, a traffic study was undertaken to determine the transportation impacts of a community center proposed opposite the Wells Avenue at Route 128 Office Park on Nahanton Street in Newton. The project, to establish what is now called the Gosman Jewish Community Campus, was a redevelopment of the structures occupying the site for reuse as a community center. At present, the work is nearly complete and the renovated buildings are partially occupied.

Access to the facility is provided via a driveway located at the intersection of Nahanton Street and Wells Avenue. Emergency access is possible by a pair of driveways on Winchester Street, which are normally blocked by chain barricades to prevent other uses and discourage traffic on Winchester Street.

The study concluded that traffic generated by the community center would not significantly impact flows in the Nahanton Street-Winchester Street area. However, existing traffic conditions at the Wells Avenue intersection were found to be hazardous, due to high travel speeds on Nahanton Street, which cause difficulty in moving from Wells Avenue onto Nahanton Street.

To address these problems the study recommended installation of a demand-actuated signal to service the intersection of the Gosman campus driveway, Wells Avenue and Nahanton Street. The new signal would provide for orderly traffic flow and would tend to lower vehicle speed on Nahanton Street. Construction of the signal is being funded by the City of Newton and was expected to begin in March of 1985.

3.2.3 Redesign for the Needham Street/Highland Avenue Corridor

In February 1982, the Massachusetts Department of Public Works released prints of plans (drawn to scale: one inch = 50 feet) of two alternative design improvements for the Highland Avenue/Needham Street corridor. The plans were drawn on aerial photos of the corridor between Route 9 in Newton and Route 128 in Needham, and were intended to provide some idea of the effect roadway improvement would have on abutting properties.

Each of the alternatives considered involve surface widening to provide a minimum of four 12-foot travel lanes. Alternative I is a 70-foot cross section which includes 8-foot shoulders, a 6-foot non-traversable median section, and 24 feet of lane surface to either side. Alternative II is a 48-foot cross section without shoulders or median. The plans do not include proposals for consolidation of curb-cuts, geometric change, or intersection signalization.

As drawn, alternative plans I and II essentially follow the centerline of the present surface alignment to indicate where alternative curb-edge lines would lie with respect to abutting buildings and structures. According to the plans presented, Alternative I (70-foot section) primarily affects off-street parking areas and would likely change existing parking patterns on either side of Needham Street and Highland Avenue and on the eastern side of Winchester Street. The 70-foot layout would also significantly reduce the walking space available to pedestrians and would in several instances greatly diminish building setback. In fact, on the southern side of Needham Street in Newton, the potential exists for several buildings to front directly on the curb-edge. It is not clear from the plans whether one existing structure would actually encroach on the new layout.

Alternative II does not appear to substantially affect building setback or off-street parking areas, since the 48-foot width falls entirely within the existing MDPW layout. On most sections the grass strip between sidewalk and curb is sufficient to accommodate required surface expansion. Sidewalk relocations may be necessary in some areas to accommodate existing facilities.

4 PHYSICAL INVENTORY

4.1 RIGHT-OF-WAY

The Needham/Newton Corridor Consensus Plan requires 72 feet of right-of-way on Highland Avenue and Needham Street. This includes a combination of five 12-foot lanes and two 6-foot sidewalks. On certain segments, four-lane sections are recommended, which would require a maximum width of 60 feet.

With the exception of the Highland Avenue Bridge at the Charles River, Massachusetts Highway Bounds (MHB) are 60-feet wide east of First Avenue in Needham as far as Winchester Street in Newton. At the Highland Avenue Bridge, the MHB expand to 86 feet to accommodate bridge footings and support abutments.

4.2 SURFACE WIDTH

The road-surface width is narrowest on the bridge, where curb-to-curb width totals 29 feet. The surface width for the remainder of Highland Avenue and Needham Street is generally 40 feet, but varies between 30 and 52 feet. A segment-by-segment inventory of physical and functional characteristics is contained in Appendix C.

The surface width is divided into two lanes by a double yellow centerline in the Needham Street section. Vehicles on this section of the corridor generally travel in a single line, weaving around left-turn vehicle queues.

In Needham, Highland Avenue begins at the Highland Avenue Bridge as two lanes and gradually expands to four by the Second Avenue intersection. The four-lane section is maintained as far west as the Hunting Road and Gould Street intersection. West of this intersection, the roadway merges into a two-lane section.

4.3 SEGMENT LENGTHS

Corridor segment lengths are as follows:

Needham and Newton

<u>Segment</u>	<u>Length (in miles)</u>
Webster St. to Route 9	2.05

Needham

<u>Segment</u>	<u>Length (in miles)</u>
Webster St. to Mills St.	.15
Mills. St. to S.B. Ramp (west side)	.14
S.B. Ramp to Route 128	.19
Route 128 to First Ave.	.22
First Ave. to Second Ave.	.14
Second Ave. to Newton City Line	<u>.17</u>
Webster St. to Newton City Line	1.01

Newton

Needham Town Line to Christine St. and Oak St.	.07
Christine St. and Oak St. to Columbia Ave.	.52
Columbia Ave. to Winchester St.	<u>.23</u>
Needham Town Line to Winchester St.	.82
Dedham St. to Route 9	<u>.22</u>
Needham Town Line to Route 9	1.04

For all practical purposes, the corridor is evenly divided between the two communities. Highland Avenue is the single longest corridor street (1.01 miles), followed by Needham Street (.82 miles) and a short segment of Winchester Street (.22 miles). Center Street in Newton, north of Route 9, is considered part of the corridor only as it relates to the westbound Route 9 ramps.

4.4 CURB CUTS

Along the 1.57-mile section of the corridor between Route 9 in Newton and First Avenue in Needham, there are some 102 curb cuts, which vary in length from 9 feet to 294.5 feet. Intersection openings account for only 19 of the total. The remaining 83 openings furnish direct access to the parking facilities of abutting businesses.

Along the north-south oriented Winchester Street segment, there are three curb cuts on the west side and eight on the east side. Among the eight on the east are two of the longest curb openings in the corridor; this side is the most extensively curb cut section, with 58 percent of the roadside uncurbed.

On .82-mile Needham Street, curb cuts are more evenly divided between sides. To the north there are 28 and to the south there are 30. In sum, these 58 curb cuts occur at the

relatively high rate of 71 per mile.¹ With curb openings in excess of 100 feet in length, the roadside is open along 40 percent of the northern and 42 percent of the southern edge.

Curbside conditions along Highland Avenue between the Newton City Line and First Avenue in Needham are similar to those found on Needham Street. Curb cuts are almost evenly split between sides: 17 on the north and 16 on the south side. Frequency is similarly high, at a rate of 70 curb cuts per mile. Roadside cuts are extensive: 36 percent of the south side and 40 percent of the north side is open.

The differences between Highland Avenue and Needham Street are that Highland has a higher rate of intersections--17 per mile versus 13 per mile on Needham Street--and has more driveway-access parking facilities than Needham Street. On Needham Street, store-front, angle parking with unlimited street access is more prevalent, particularly along eastern portions.

4.5 PAVEMENT CONDITIONS

Resurfaced last in August of 1980, surface condition along all segments of the corridor is good, although two problem areas exist on Needham Street:

- o the at-grade rail crossing; and
- o the Christina Street intersection.

At the railroad crossing, the pavement has receded from the rail flange and raveling is apparent at the pavement edge. At the Christina Street intersection, substantial rutting has developed on the southwestern quadrant where the pavement meets a gravel shoulder. Westbound Needham Street traffic circumventing left-turn queues for Oak Street often uses the shoulder and has displaced the base over time.

The road-surface markings are particularly worn on the portions of the corridor east of Route 128. Edge detection is par-

¹Walton, C. Michael et al., "Accident and Operational Guidelines for Continuous Two-Way Left-Turn Median Lanes," Traffic Control Devices, Geometrics, Visibility and Route Guidance, (Transportation Research Record 737, Transportation Research Record). In their discussion of physical characteristics affecting the safety of road segments, the authors allude to the importance of the number of driveways per mile as a descriptor of the level of roadside development. In Table 3 (page 50), the authors use frequencies greater than 60 driveways/mile to indicate high levels of development and less than 40 driveways/mile to indicate low levels of development.

ticularly difficult on most segments due to the absence of sidelines, instances of deteriorated curb reveal, and extensive at-grade driveway openings.

4.6 PARKING

On-street parking is governed by Massachusetts state law, which does not permit parking on thoroughfares under the Commonwealth's jurisdiction. At present, the practice of on-street parking is apparent in only two areas of the corridor. Long-term parking is present on the westbound Route 9 on-ramp, and delivery vehicles make short-term curbside stops to unload goods on the south side of Highland Avenue east of Second Avenue.

While the on-street parking is not particularly disruptive to traffic flow along the corridor, off-street parking operations often interfere with traffic operations along Winchester Street and on eastern sections of Needham Street. Parking is difficult and unsafe in several locations where off-street spaces border the roadway. To provide the maximum amount of storefront parking, angle spaces are typically designated along open drives which commonly extend for the length of the parcel. Access to and from lots is random, and limitations on space within the facility often force vehicles to compete with street traffic to complete entrance/exit maneuvers.

4.7 SIDEWALKS

Frequently interrupted by driveways, sidewalks are intermittently present on both sides of the corridor. Typical widths range between 4 and 6 feet, with 2-3 foot grass strips between the curb and the walking surface.

4.8 DRAINAGE

Storm sewers are present on either side of all corridor segments in both Needham and Newton. Weather-related flooding problems are not apparent, except that localized flooding sometimes occurs in the winter when sand and snow block sewers.

4.9 LIGHTING

On Highland Avenue in Needham, all overhead street lighting is positioned on the south side of the street. With the exception of the Route 128 overpass, coverage is limited to intersection locations. Coverage on all sections of Highland Avenue is adequate, however, because of the high frequency of intersections.

On Needham Street in Newton, streetlights are posted at regular intervals on alternate sides of the street. The higher frequency of lights provides better overall coverage than that on Highland Avenue.

5 TRAFFIC VOLUME

5.1 MECHANICAL COUNTS

In March of 1982 and October of 1983 the Massachusetts Department of Public Works (MDPW) conducted traffic counts covering some 37 locations in the Needham Street/Highland Avenue study area. In addition, a limited number of locations were also surveyed in September and October of 1984 by CTPS. Locations were surveyed using mechanical traffic recorders for periods of time ranging from 24 hours to 7 days.

Average daily traffic (ADT) for typical 24-hour periods is enumerated by survey location in Tables 5-1 and 5-2. To derive ADTs from the counts, the count sample is totaled and divided by the number of 24-hour periods covered. (For analysis purposes, 1983 ADTs are used, since these counts were more extensive.) In this manner, ADTs were developed for 1983 as shown by location in Figure 5-1.

5.2 ADT CHARACTERISTICS

As indicated in Figure 5-1, corridor traffic is heaviest on Highland Avenue in the vicinity of the Route 128 ramps in Needham. Treating the ramp system as a central locus, study-area traffic volumes generally decline in proportion to distance from the center. There is one exception to this rule.

Traffic volumes on First Avenue (ADT of 7900) are lower than those on the more distant Second Avenue (CTPS estimate not shown; 10,500 in 1983). This is because Highland Avenue is median-separated at the point of intersection with First Avenue.

The median divider was extended east of First Avenue in 1976 to prevent First Avenue traffic from crossing eastbound traffic on Highland Avenue. Prior to extension of the median, unsafe vehicle queuing often occurred on the northbound Route 128 exit ramp to Highland Avenue during peak periods.

The median barrier also caused a shift in traffic patterns that is reflected in relatively low traffic volumes on First Avenue and higher volumes on Hunting Road. The median causes First Avenue to function primarily as an entrance to the New England Industrial Center (NEIC). Traffic exiting the NEIC in the direction of Route 128 or points west has three options:

Street	Count Location	Volume
Highland Ave.	Between First Ave. & Second Ave.	33,000**
Needham St.	E. of Oak St.	28,050*
	W. of Oak St.	27,100*
	Between Columbia Ave. & Winchester St.	22,800**
	Between Columbia Ave. & Jaconnet St.	22,850**
First Ave.	S. of Highland Ave.	7,900**
Third Ave.	N. of Kendrick St.	3,800**
Fourth Ave.	N. of Kendrick St.	5,550**
Christina St.	S. of Needham St.	2,350**
Hunting Rd.	S. of Highland Ave.	10,500*
	N. of Kendrick St.	10,450**
Gould St.	N. of Highland Ave.	9,500*
Webster St.	S. of Greendale Ave.	6,300**
Greendale Ave.	E. of Webster St.	1,750*
	N. of Kendrick St.	6,500**
	S. of Kendrick St.	1,200**
Kendrick St.	E. of Hunting Rd.	14,150*
Wells Ave.	S. of Nahanton St.	8,050*
Winchester St.	Between Route 9 Ramps & Dedham St.	25,450**
	Between Dedham St. & Columbia Ave.	4,800**
	Between Columbia Ave. & Jaconnet St.	4,700**
Columbia Ave.	Between Needham St. & High St.	350**
Nahanton St.	E. of Wells Ave.	14,700**

*24 hours only

**48 hours

Highland Avenue/ Needham Street Traffic Analysis	1984	CTPS
Technical Report 56a August 1986	MDPW AWDT TRAFFIC COUNTS	TABLE 5-1

Street	Count Location	Count Period	Volume
Needham St.	EB at Charles River	(9/24-9/28)	14,228
	WB at Charles River	(9/24-9/28)	15,091
	WB at Charles River	(9/17-9/20)	14,304
	EB at Newton Engineering	(9/17-9/20)	12,768
	WB at Boston Desk	(9/17-9/21)	11,301
	WB at Boston Desk	(9/24-9/28)	11,563
Winchester St.	South of Route 9	(Oct.)	24,985
Route 9 EB On/Off Ramp	East of Winchester St.	(Oct.)	8,758
Route 9 WB On/Off Ramp	West of Centre St.	(Oct.)	4,741
Centre St.	East of Route 9	(Oct.)	24,648

Highland Avenue/
Needham Street
Traffic Analysis

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1984
CTPS AWDT TRAFFIC COUNTS

CTPS

TABLE

5-2

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- o Exit at First Avenue and U-turn at the median-end near Wexford Street
- o Exit on Second Avenue
- o Exit onto Kendrick Street, cross Route 128, and access Hunting Road

The circuitous Hunting Road path serves two trip types: those exiting the NEIC and trips to and from the Wells Avenue at Route 128 Office Park. The travel times of this longer route become competitive during periods of peak travel, when congestion lessens the time advantage of First Avenue or Second Avenue exit routes.

5.3 TURNING-MOVEMENT COUNTS

Turning-movement counts were conducted at selected intersections throughout the study area during the fall of 1984. In total, 16 locations were sampled during the periods:

7:00 AM - 9:00 AM (AM)
11:00 AM - 1:00 PM (MID)
4:00 PM - 6:00 PM (PM)

For each two-hour period, vehicle movements were totalled by quarter hour. The data were subsequently summarized for each hour on the quarter hour to determine AM, MID, and PM peak hours. Peak hours, therefore, represent the sum of the four highest consecutive quarter hours of each two-hour sampling period. Study-area peak hours are specified by location and date of survey in Table 5-3.

Examination of peak-hour occurrence reveals that there is a tendency of traffic to peak in sequence across the study area according to the traffic-generating characteristics of local/adjacent land use. This finding is predictable inasmuch as different land uses generate peak traffic volumes at different times; e.g., office and retail districts tend to have different peak times.

This tendency of area traffic activity to display discrete peaking characteristics by location is demonstrated in Table 5-4. As shown in the table, the intersections selected are primarily influenced by one of the four basic land-use types present in the study area. Intersections influenced primarily by the NEIC experience peak traffic conditions earliest in both the AM (7:30-8:30) and the PM (4:15-5:15 or 4:30-5:30) periods. The intersection which best represents the effects of an office park on traffic is Nahanton Street at Wells Avenue in Newton. Traffic here peaks slightly later than in the industrial NEIC area in the morning (8:00-9:00 AM) and at approximately the same time in the evening (4:30-5:30 PM). Those intersections influenced mostly by

Location	Community	Date	Peak Hour		
			AM	MID	PM
Nahanton St. @ Wells Ave. & Jewish Community Campus	Newton	9-19-84	8:00-9:00	12:30-1:30	4:30-5:30
Kendrick St. @ Third Ave.	Needham	9-20-84	7:30-8:30	11:45-12:45	4:15-5:15
Kendrick St. @ Fourth Ave.	Needham	9-20-84	7:45-8:45	12:00-1:00	4:30-5:30
Kendrick St. @ Hunting Rd.	Needham	9-19-84	7:30-8:30	12:00-1:00	4:45-5:45
Kendrick St. @ Greendale Ave.	Needham	9-20-84	7:45-8:45	12:00-1:00	4:30-5:30
Greendale Ave. @ Webster St.	Needham	9-19-84	7:45-8:45	12:00-1:00	4:45-5:45
Highland Ave. @ Webster St.	Needham	9-19-84	7:45-8:45	12:00-1:00	4:45-5:45
Highland Ave. @ Hunting Rd. & Gould St.	Needham	9-20-84	8:00-9:00	12:30-1:30	5:00-6:00
Highland Ave. @ First Ave.	Needham	9-20-84	7:45-8:45	12:30-1:30	4:15-5:15
Highland Ave. @ Second Ave.	Needham	9-18-84	7:30-8:30	12:30-1:30	4:15-5:15
Highland Ave. @ Wexford St.	Needham	9-18-84	8:15-9:15	12:30-1:30	4:15-5:15
Needham St. @ Oak Street & Christina St.	Newton	9-18-84	7:45-8:45	12:00-1:00	4:30-5:30
Needham St. @ Tower Rd.	Newton	9-20-84	8:00-9:00	11:45-12:45	4:45-5:45
Needham St. @ Dedham St. & Winchester St.	Newton	9-20-84	8:00-9:00	12:30-1:30	5:00-6:00
Winchester St. @ Route 9 Eastbound On/Off Ramp	Newton	10-17-84	8:00-9:00	12:15-1:15	4:45-5:45
Centre St. @ Route 9 Westbound On/Off Ramps	Newton	10-16-84	7:45-8:45	12:30-1:30	5:00-6:00

Highland Avenue/ Needham Street Traffic Analysis	PEAK-HOUR TIMES BY LOCATION AND DATE		CTPS
	Technical Report 56a August 1986		TABLE 5-3

Intersection	Peak Hour	
	AM	PM
Intersections Directly Influenced by the New England Industrial Center		
Kendrick St. at: Third Ave.	7:30-8:30	4:15-5:15
Fourth Av.	7:45-8:45	4:30-5:30
Highland Ave. at: First Ave.	7:45-8:45	4:15-5:15
Second Ave.	7:30-8:30	4:15-5:15
Intersections Directly Influenced by the Office Park at Route 128		
Nahanton Street at: Wells Ave. & the Jewish Community Campus	8:00-9:00	4:30-5:30
Intersections Directly Influenced by Study Area Retail and Residential Developments		
Highland Ave. at: Hunting Rd. & Gould St.	8:00-9:00	4:45-5:45
Needham St. at: Tower Road	8:00-9:00	4:45-5:45
Dedham St. & Winchester St.	8:00-9:00	5:00-6:00

Highland Avenue/ Needham Street Traffic Analysis	TRAFFIC-PEAKING CHARACTERISTICS OF SELECTED STUDY-AREA INTERSECTIONS	CTPS
		TABLE 5-4
Technical Report 56a August 1986		

local retail and residential development peak latest in both the morning (8:00-9:00 AM) and the evening (4:45-5:45 PM or 5:00-6:00 PM). Most of the remaining intersections in the study area exhibit a mix of peak-hour times due generally to a combination of land-use influences.

As described above, the area's diversity of land uses causes traffic to peak successively depending on the location. This condition is compounded by the area's dense level of development, which generates high levels of traffic at each succeeding peak. In combination, these factors cause isolated peak flows to overlap and the area as a whole to experience high volumes throughout peak periods. In fact, peak-hour volumes at most area intersections are only slightly higher than volumes from surrounding hours.

Table 5-5 is a compilation of the percentage differences which exist between morning and evening peak hours and the next-highest hour occurring in each time period. On average, AM peak hours differ from the next-highest AM hour by only 2.7%. During the peak evening period the mean difference drops to 2.2%. These small differences suggest the maintenance of high levels of traffic throughout peak periods.

From a land-use perspective, while it is the combination of diversity and density factors which gives rise to extended peaks, it is the diversity of the area which spreads traffic relatively evenly over the peak. In the absence of diversity, the pressure of high land-use density would cause traffic demands to spike sharply higher, although possibly for shorter periods. Land-use diversity is consequently beneficial to the area, since it actually diverts peak-hour demands away from a uniform time.

5.4 FLOW DIAGRAMS

Certain sections of the study area do, however, experience greater travel demands and consequently higher concentrations of traffic than do others. A series of traffic-flow diagrams which identify areawide traffic volumes by location and direction are presented in Figures 5-2 through 5-4. The source of these diagrams is the CTPS turning-movement survey conducted in September and October of 1984. For the sake of consistency, common morning (7:30-8:30 AM), midday (12:00-1:00 PM), and evening (4:15-5:15 PM) peak hours were selected, on the basis of overall frequency. As a consequence, areawide peak hours do not necessarily reflect actual peak-hour volumes for each location.

5.4.1 Total Volume

On Highland Avenue, traffic concentration is consistently highest in the vicinity of Route 128. The effects of Route 128 on area traffic are also apparent on Needham Street, where traffic volumes are typically highest near the Oak Street/Christina

Intersection	Percent Difference	
	A.M.	P.M.
Centre Street/Winchester Street at Rte. 9 Westbound On/Off Ramps	0.8	0.2
Winchester Street at Rte. 9 Eastbound On/Off Ramp	3.3	0.8
Needham Street at Winchester Street & Dedham Street	3.4	1.7
Needham Street at Tower Road	0.6	1.4
Needham Street at Oak Street & Christina Street	0.5	1.7
Highland Avenue at Second Avenue	1.2	0.6
Highland Avenue at Wexford Street	2.9	1.5
Highland Avenue at First Avenue	0.1	1.1
Highland Avenue at Hunting Road & Gould Street	2.1	2.4
Highland Avenue at Webster Street	0.9	0.2
Webster Street at Greendale Avenue	0.8	1.3
Greendale Avenue at Kendrick Street	7.8	2.5
Hunting Road at Kendrick Street	9.3	2.4
Kendrick St. at Third Avenue	2.0	1.3
Kendrick St. at Fourth Avenue	2.4	4.7
Nahanton St. at Wells Avenue & Jewish Community Campus	5.2	13.0
	mean = 2.7	mean = 2.2

Highland Avenue/ Needham Street Traffic Analysis	PERCENT DIFFERENCE BETWEEN PEAK-HOUR AND NEXT-HIGHEST- HOUR TRAFFIC	CTPS
Technical Report 56a August 1986		TABLE 5-5

CTPS

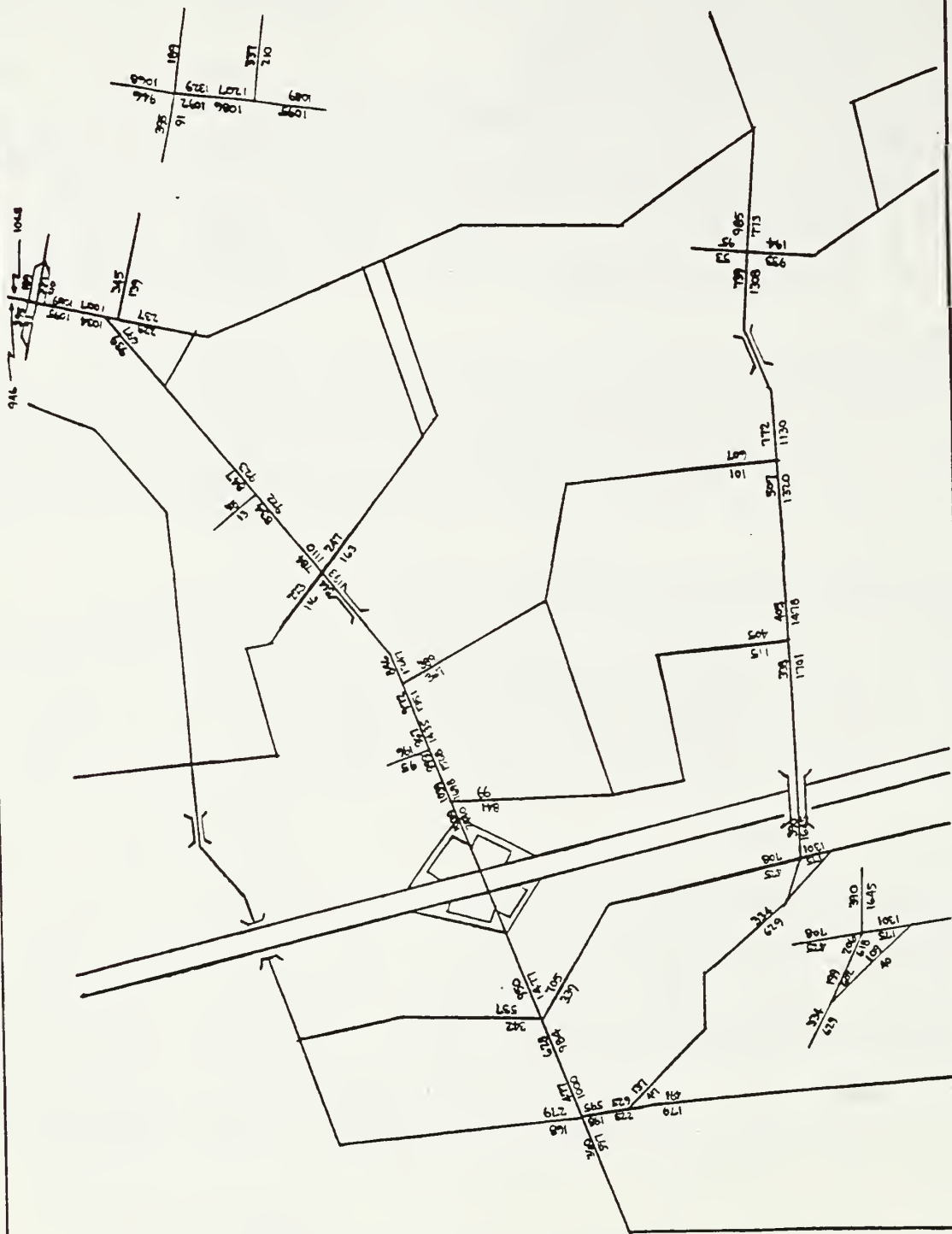
FIGURE

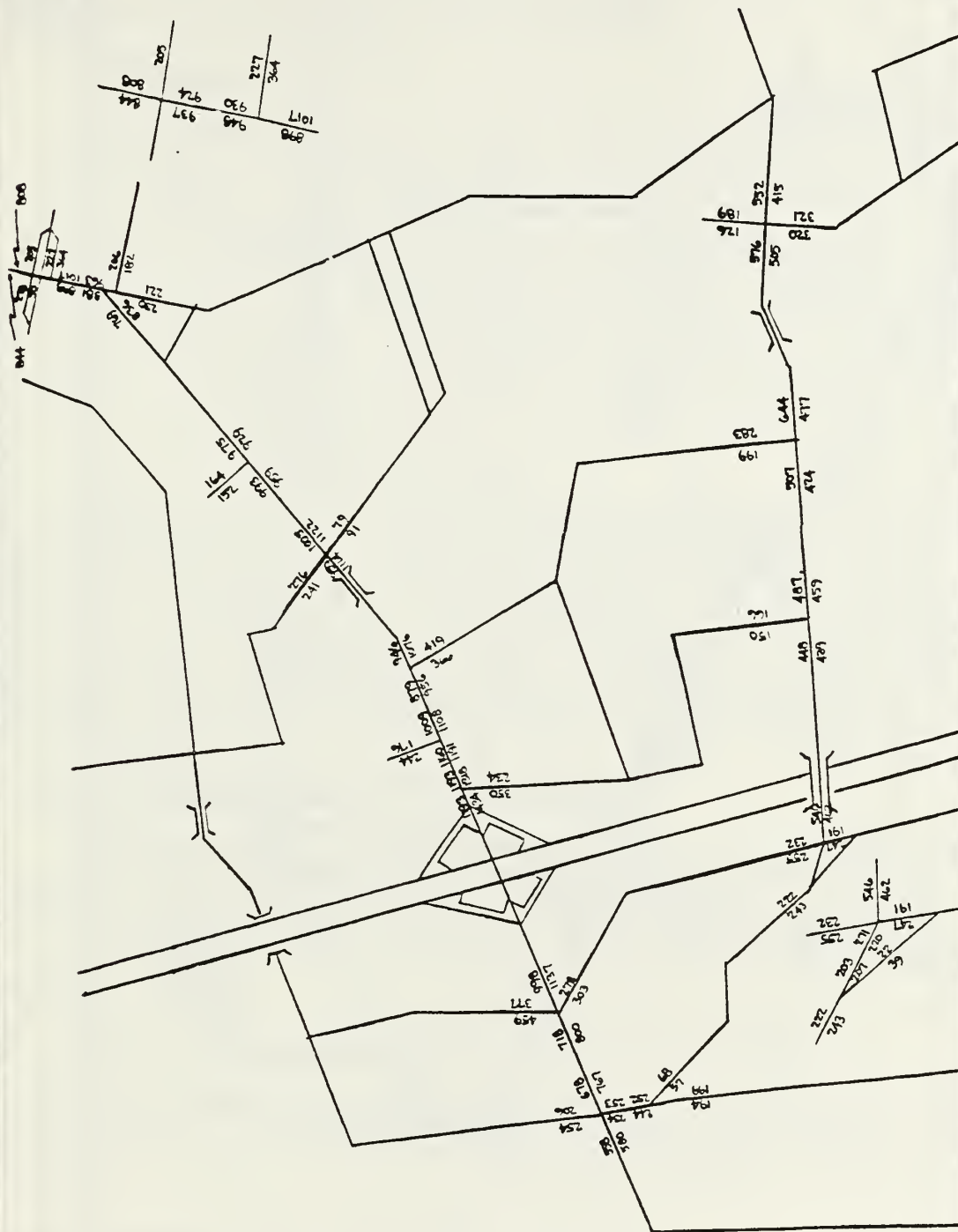
5-2

AM-PEAK-HOUR (7:30-8:30 AM)
DIRECTIONAL TRAFFIC FLOWS

NOT TO SCALE

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CTPS

FIGURE

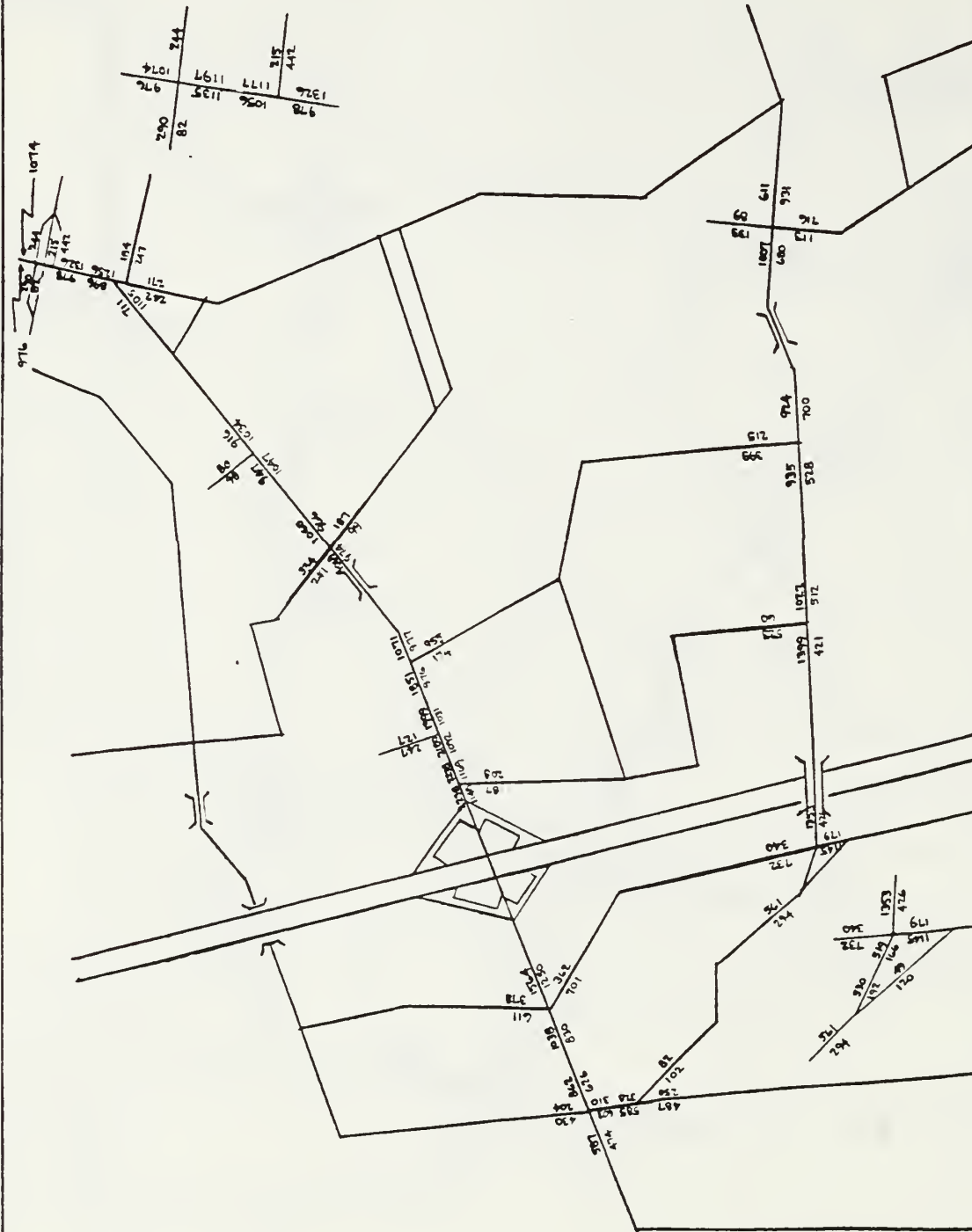
5-3

MIDDAY-PEAK-HOUR (12:00-1:00 PM)
DIRECTIONAL TRAFFIC FLOWS

NOT TO SCALE



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CTPS

FIGURE

5-4

EVENING-PEAK-HOUR (4:15-5:15)
 DIRECTIONAL TRAFFIC FLOWS

NOT TO SCALE

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Street intersection. During AM and PM peak hours, traffic totals along Kendrick Street and Nahanton Street display an east-to-west pattern comparable in magnitude to Needham Street. Midday peak-hour traffic on Needham Street is roughly twice that of the Kendrick Street/Nahanton Street segment.

5.4.2 Direction of Flow

Study-area traffic volumes exhibit considerable shifts in direction of flow by time of day. In the morning, work trips depart Needham and Newton along the Highland Avenue/Needham Street corridor in the direction of Route 128. Route 128 in turn provides an even higher volume of trips to employment destinations along Kendrick Street/Nahanton Street, Highland Avenue/Needham Street, and Gould Street. With the exception of Highland Avenue/Needham Street, the process is largely reversed during the PM peak. On Highland Avenue and Needham Street, work-trip effects on direction are diluted during the PM peak by the addition of a significant number of non-work trips, which results in more of a balance between the eastbound and westbound flows.

Midday traffic in the study area appears to have little directionality in most cases. The primary exception is a slight eastbound direction on Highland Avenue beginning east of Route 128 and continuing to the area approximately bounded by Marshall's Plaza and the McDonald's/Tang Dynasty restaurant/retail area. Similarly, from the east there is a westbound flow from the Route 9 and Newton area. In the discussion which follows, midday directionality will be addressed only for those specific locations which have traits which diverge from the norm.

Highland Avenue (West of Route 128)

During the morning peak hour, traffic on Highland Avenue is directionally oriented (61 percent at Gould Street, 68 percent at Webster Street) eastbound from Needham toward Route 128. The pattern is reversed in the evening as traffic becomes predominantly westbound (55 percent at Gould Street, to 58 percent at Webster Street).

Gould Street (at Highland Avenue)

Gould Street traffic is 61-percent northbound in the morning and 62 percent southbound in the evening. The pattern results from work trips to and from employment areas on Gould Street and environs.

Hunting Road

At Highland Avenue, Hunting Road traffic moves predominantly northbound (67 percent) in the morning, reversing direction to southbound (66 percent) in the evening. This pattern is indicative of Hunting Road's function as an importer/exporter of work

trips to and from Gould Street and Route 128 during the morning and evening peaks.

South of Kendrick Street, morning and evening directional shifts are more pronounced. Peak traffic is 88-percent northbound during the evening peak. These shifts are due to the peak periods' function of importing/exporting work trips for employment centers on Kendrick Street/Nahanton Street, Highland Avenue (both east and west), and Gould Street.

Greendale Avenue (North of Kendrick Street)

Supplying trips to and from the employment areas along Kendrick Street and Nahanton Street, Greendale Avenue traffic is 65-percent eastbound in the morning and 66-percent westbound in the evening.

Kendrick Street

West of Hunting Road, Kendrick Street functions in conjunction with Greendale Avenue, importing work trips destined for the industrial and office parks east of Route 128 in the morning and exporting these work trips in the evening. Eastbound traffic accounts for 75 percent of the flow in the morning and westbound movement accounts for 76 percent in the evening.

East of the NEIC entrances at Third Avenue and Fourth Avenue, morning eastbound flows decline from 88 to 59 percent. During the evening, traffic moving westbound is 57 percent of the total east of Fourth Avenue and 77 percent west of Third Avenue.

Nahanton Street

The Wells Avenue at Route 128 Office Park is a focus of AM and PM peak-period traffic. In the AM, east of Wells Avenue traffic flows are 56 percent in the westbound direction, whereas to the west of Wells Avenue 64 percent of the traffic moves in an eastbound direction.

During the PM peak, the directional splits east and west of the office park are symmetrical. Traffic flows heading westbound are 60 percent of the total immediately to the west, and eastbound flows are 60 percent of the total immediately to the east.

Fourth Avenue (at Kendrick Street)

Morning traffic on Fourth Avenue is 86-percent northbound/inbound to the NEIC. Evening flows are reversed--oriented southbound/outbound, but to a lesser (65 percent) degree. Midday flows favor the inbound movement 59 percent to 41 percent.

Third Avenue (at Kendrick Street)

In conjunction with Fourth Avenue, Third Avenue also imports trips to the NEIC in the morning. Overall, 78 percent of the flow is northbound, a level slightly below that experienced at Fourth Avenue. However, during the evening period Third Avenue becomes the dominant traffic carrier of the entrance/exit pair, with 90 percent of the flow moving in the southbound direction.

Highland Avenue (East of Route 128)

AM-peak volumes are directed most heavily (70 percent) eastbound west of First Avenue. This percentage is lower to the east, declining to 60 percent immediately east of Second Avenue. PM-peak flows reflect a reversal of this pattern: immediately east of Second Avenue, 52 percent of the flow is westbound; to the west, toward Route 128, the flows become decidedly more westbound, reaching 66 percent of the total at First Avenue.

First Avenue (at Highland Avenue)

AM-peak volumes are heaviest in the southbound direction, since First Avenue serves as the primary means of access to the NEIC from the north. In total, some 90 percent of the traffic is southbound/inbound during the morning period. During the evening, the inbound movement continues to dominate the flow by a 60 percent to 40 percent margin. The failure of morning and evening flows to move in opposite directions is a consequence of the right-turn-only restriction on exiting traffic.

Second Avenue (at Highland Avenue)

AM-peak traffic is split evenly between the northbound and southbound directions. When viewed in total, the AM-peak direction of flow to the NEIC is inbound/southbound from Highland Avenue. The proximity of First Avenue to Route 128 causes it to service a higher number of these trips than Second Avenue. The left-turn prohibition from First Avenue to Highland Avenue causes Second Avenue to carry higher volumes of exiting/northbound traffic. During the AM peak this condition is reflected in a fairly even split of traffic on Second Avenue and a 90-percent southbound directed flow on First Avenue. PM-peak flows on Second Avenue are directed 85-percent northbound/outbound.

Needham Street

At the Oak Street/Christina Street intersection, 59 percent of the morning traffic is headed east. During the midday and evening periods the directional split becomes less well defined.

Further east, at the Tower Road intersection, traffic is almost evenly split east/west throughout the day. At this point, opposing demands from either end of Needham Street converge.

At its easternmost point, the Winchester Street intersection, morning and evening peak directions are the inverse of the more westerly intersections of Highland Avenue at First Avenue and Second Avenue and of the Oak Street/Christina Street intersection. AM traffic immediately west of Winchester Street is 57-percent westbound. PM traffic reverts to an eastbound direction, with 61 percent in that direction during the peak.

Winchester Street

South of Dedham Street, Winchester Street exhibits the most minor of directional tendencies throughout the day. Traffic flows are 51-percent northbound in the AM and 53-percent northbound in the PM. Midday flows are a marginal 51-percent southbound.

Immediately north of Dedham Street, 51 percent of the morning traffic is oriented to the south. PM flows are reversed and more pronounced, with 58 percent directed northbound.

South of Route 9, AM-peak traffic is evenly split. PM-peak flows, however, continue to be distinctly northbound, with 58 percent headed in the direction of Route 9 and Newton Centre.

Eastbound Route 9 On/Off Ramp (at Winchester Street)

Ramp traffic is oriented toward Winchester Street (62 percent westbound) during the AM and toward Route 9 (67 percent eastbound) during the PM period. Midday flows have an eastbound, Route 9 orientation, with 62 percent headed in that direction.

Westbound Route 9 On/Off Ramp (at Centre Street)

Traffic on the ramp heavily favors the westbound/Route 9 direction throughout the day (81% AM; 85% midday; and 78% PM). The consistency of these flows is indicative of the primary function of the segment as a Route 9 on-ramp.

Dedham Street (at Winchester Street)

At Dedham Street the majority of traffic (71 percent) flows into the Winchester Street/Needham Street intersection during the morning and away from the intersection (57 percent eastbound) during the evening.

Tower Road

Tower Road is typical of the one-block, dead-ended local streets intersecting Needham Street which provide direct access to buildings and property set back from the major street. Carrying low volumes of traffic, Tower Road's AM-peak direction is predominantly (66-percent) northbound--away from Needham Street. PM traffic must access Needham Street to exit the area and is 55-percent southbound.

Christina Street

Christina Street does not exhibit the typical morning-to-evening reversal found on most other study-area facilities. Instead, morning and evening flows are predominantly oriented in the direction of Needham Street. During the morning this amounts to 60 percent of the flow and in the evening 65 percent.

Oak Street

Oak Street traffic flows are consistent with Christina Street movements by time of day. As Christina Street functions as an importer of trips to the intersection during peak hours, Oak Street serves as an exporter of trips. The degrees of directionality of the two facilities, however, do not match: Oak is 66-percent northbound in the morning and 57-percent northbound in the evening. This difference is due in part to a relatively low volume of trip exchange between Oak Street and Christina Street.

5.5 TIME-OF-DAY CHARACTERISTICS

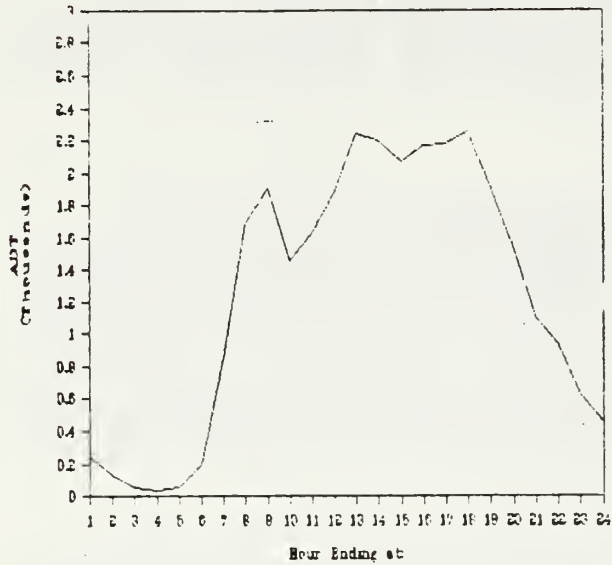
The distribution of traffic volume over a 24-hour period provides further indications of the relationship between peak and off-peak conditions. In Figures 5-5 and 5-6 the 1983 MDPW 24-hour ADT volumes are plotted for selected locations. In general, the traffic distributions shown in Figure 5-5 for Highland Avenue and Needham Street indicate a high-level demand that is continuous through midday/off-peak periods. On the other hand, the Figure 5-6 distributions for Kendrick Street and Hunting Road reflect relatively low midday travel demand with high morning and evening demand, to form a bi-modal distribution over 24 hours.

Specifically, on Highland Avenue and Needham Street, traffic volumes tend to rise sharply by 6 AM, moderate slightly before reaching a midday peak, and moderate again before reaching an evening peak. Morning, midday, and evening peaks are present in these patterns; however, the distribution is relatively flat, with only slight variation between peak and off-peak times. This relatively level demand is indicative of a large volume of shopping and lunch trips destined for the area's retail establishments and restaurants. Underlying these demands is the continuous use of the road as a connector for through trips between Route 128/I-95, Route 9, and I-90.

Traffic in most other sectors of the study area display time-of-day distributions such as those shown in Figure 5-6. Following a similar pattern in the morning, travel increases rapidly beginning at approximately 6 AM, due primarily to work-trip demands. Midday travel is, however, significantly more shallow, and travel begins to increase again only as employees begin lunchtime activities. In the Webster Street example, work-trip travel is present, but to a lesser extent than on the other

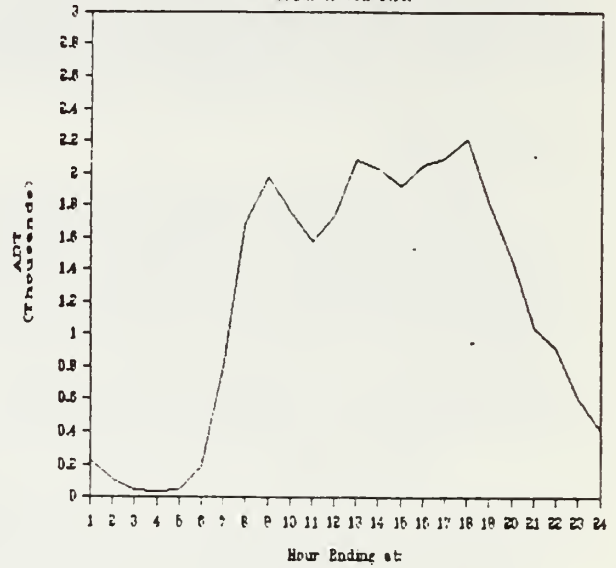
Needham Street

North of Oak Street



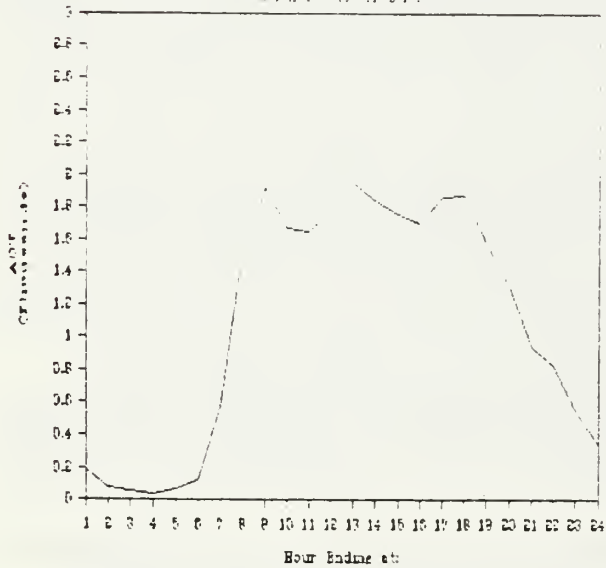
Needham Street

South of Oak Street



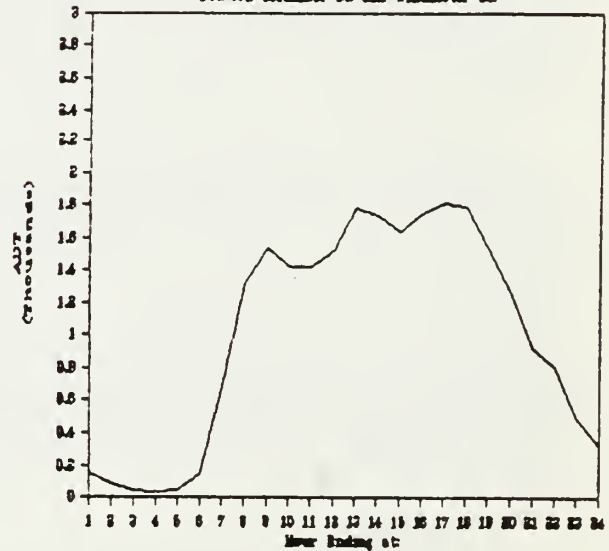
Highland Avenue

North of Webster Street



Needham Street

Between Columbia St. and Winchester St.



Highland Avenue/
Needham Street
Traffic Analysis

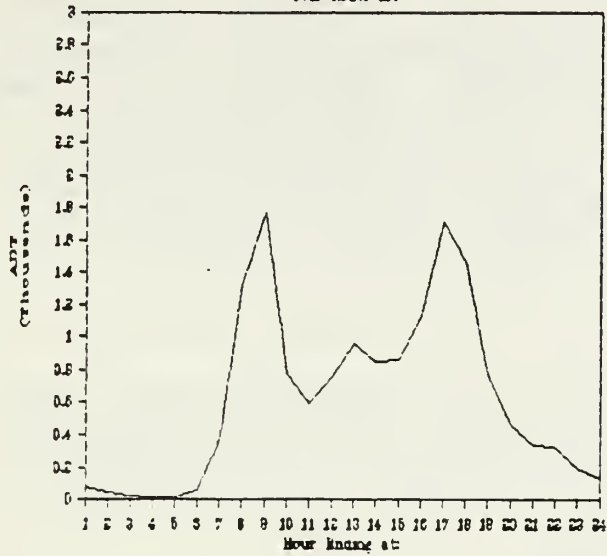
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TIME-OF-DAY TRAFFIC DISTRIBUTIONS
ON
HIGHLAND AVENUE AND NEEDHAM STREET

CTPS
FIGURE
5-5

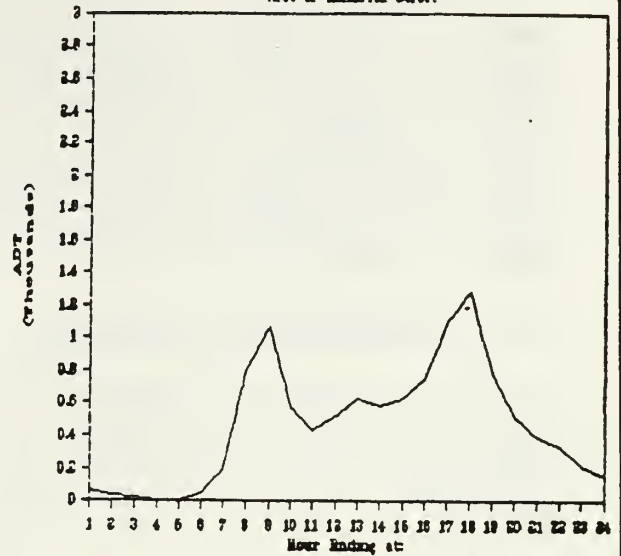
Kendrick Street

Over Route 123



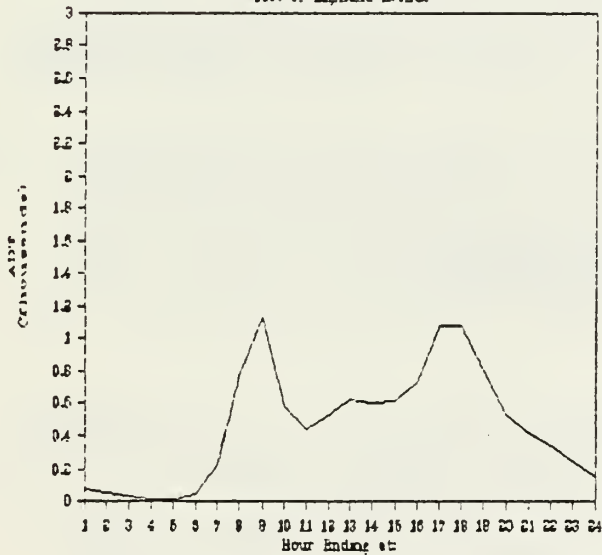
Hunting Road

West of Kendrick Street



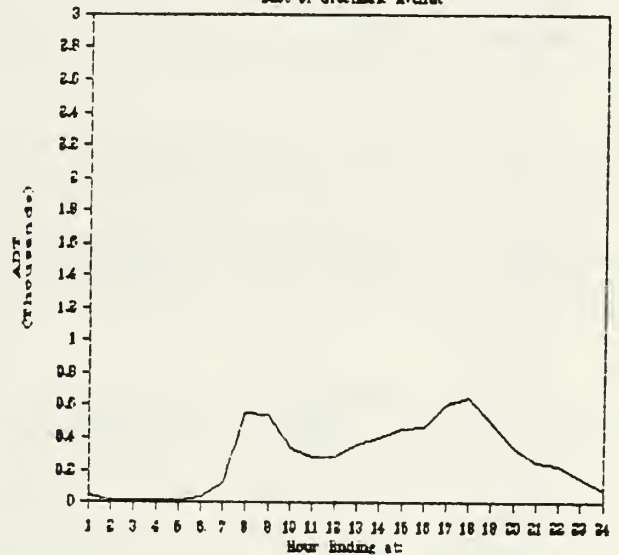
Hunting Road

East of Highland Avenue



Webster Street

East of Greenland Avenue



Highland Avenue/
Needham Street
Traffic Analysis

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TIME-OF-DAY TRAFFIC DISTRIBUTIONS
OFF
HIGHLAND AVENUE AND NEEDHAM STREET

CTPS

FIGURE

5-6

facilities; also, during the afternoon period a more general-purpose use of the road is apparent in the flattened curve which develops.

Clearly, the persistently high traffic flows on Highland Avenue and Needham Street cause traffic to operate at peak-period levels of service through most of the day. This lack of off-peak relief creates a travel environment that may cause excessive vehicle delay at any time. In areas away from Highland Avenue and Needham Street, low levels of service may temporarily occur during morning and evening peak periods; however, these conditions are generally brief in duration and not present at other times of the day.

5.6 VEHICLE-MILES OF TRAVEL

The concept of vehicle-miles of travel (VMT) is used extensively in traffic analysis as a measure of utility and exposure. Simply defined, $VMT = \text{traffic volume} \times \text{length}$. VMT is therefore the number of miles vehicles are driven over a specified road segment.

The 1983 VMT estimates for Needham Street and Highland Avenue within the study area are derived in Table 5-6. In Needham, Highland Avenue extends approximately 1.01 miles, from Webster Street to the Newton City Line. Average daily traffic (ADT) volumes sampled at sites along this portion of Highland Avenue range between 24,700 and 46,100 vehicles. A weighted average of these totals provides an estimate of daily VMT of 36,175 on Highland Avenue. Similarly weighting volume totals by segment length on Needham Street in Newton gives an approximate daily VMT of 21,727.

Using this concept in reverse (dividing VMT by distance), it is possible to derive ADT volumes for selected road segments. Estimates of ADT for selected portions of Highland Avenue and Needham Street are given at the end of Table 5-6. On average, Needham Street and Highland Avenue between Second Avenue and Winchester Street carried an average of 26,600 vehicles per day in 1983.

The measures of VMT developed in Table 5-6 will be used in the following chapter to derive location-specific accident-rate statistics. But the estimates of ADT by segment presented at the bottom of the table have a more immediate importance. In his discussion of the applicability/utility of "continuous two-way left-turn median lanes" (CTWLTM), Nemeth notes that CTWLTM installations have been successfully built on arterials under traffic volumes ranging from 8,000 to 31,000 ADT.¹ The upper

¹Nemeth, Zoltan A., "Development of Guidelines for the Application of Continuous Two-Way Left-Turn Median Lanes" (Ohio State University, Report No. Ohio-DOT-09-76, July 1976).

Needham

	<u>Length (miles)</u>	<u>ADT</u>	<u>Daily VMT</u>
<u>Highland Avenue:</u>			
Newton City Line to Second Ave.	.17	27,100	4,607
Second Ave. to First Ave.	.14	33,000	4,620
First Ave. to Route 128	.22	46,100	10,142
Rte 128 to SB. Ramp (westside)	.19	39,700	7,543
SB Ramp (westside) to Mills St.	.14	39,700	5,558
Mills St. to Webster St.	<u>.15</u>	24,700	<u>3,705</u>
Total	1.01		36,175

Newton

Needham Street:

Winchester St. to Columbia Ave.	.23	22,800	5,244
Columbia St. to Christina St. @ Oak St.	.52	28,050	14,586
Christina St. @ Oak St. to Needham Town Line	<u>.07</u>	27,100	<u>1,897</u>
Total	.82		21,717

Average ADT Estimates
for Selected Sections

<u>Location</u>	<u>Length</u>	<u>Daily VMT</u>	<u>ADT 1983 Average</u>
Second Ave. to Winchester St.	.99	16,334	26,600
Winchester St. to First Ave.	1.13	30,054	27,393
Winchester St. to Webster St.	1.83	57,902	31,640

Highland Avenue/
Needham Street
Traffic Analysis

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HIGHLAND AVENUE AND NEEDHAM STREET
1983 VMT ESTIMATION

CTPS

TABLE

5-6

limit of ADT is important in the case of Highland Avenue and Needham Street since, as traffic volumes approach capacity, the availability of acceptable gaps in oncoming traffic becomes so low that the practicality of a CTWLTML is questionable. On Needham Street and Highland Avenue between Winchester Street and Second Avenue, ADT is within the prescribed 8,000-31,000 range for CTWLTML installation. West of Second Avenue the ADT volumes derived from MDPW traffic counts (shown at the top of Table 5-6) exceed the 31,000 ADT cited in the literature as the upper end of the useful range. It should be noted that the cited range is not intended to be either a warrant or a limitation, but is rather a representation of the conditions under which central turn lanes have been installed.

6 ACCIDENT CHARACTERISTICS

6.1 ACCIDENT-STATISTIC RESOURCES

Accident statistics for the study area were acquired from police files in Needham and Newton and from the Massachusetts Department of Public Works (MDPW). The most current data are found in police records, which are complete through 1983. Summaries supplied by the Massachusetts Registry of Motor Vehicles to the MDPW are available only through 1981.

More importantly, internal constraints experienced by the MDPW in 1981 led to a reduction in the data-compilation effort. A sample comparison of data from each of the two sources for 1981 is shown in Table 6-1 below:

TABLE 6-1

Traffic-Accident-Data Source Comparison (1981)

<u>Street Name</u>	<u>MDPW Records</u>	<u>Community Records</u>
Highland Avenue	62	135
Needham Street	24	151

This comparison clearly shows that the 1981 MDPW reports are far less comprehensive than the local police files. In addition, investigation of the police files indicated that the accident-reporting practices of Needham and Newton are substantially consistent. Therefore, local police accident reports for the three-year period ending in 1983 are used here for analysis purposes. The annual accident totals and average per year for the three-year period are listed by location in Tables 6-2 and 6-3.

6.2 ACCIDENT ANALYSIS

To identify where accident problems exist within the study area, the three-year mean number of accidents serves as a basis. The measure used for preliminary evaluation of safety conditions is the ratio of accidents to one million vehicle miles of travel (accidents/MVM), commonly referred to as the accident rate.¹

¹The formula to derive accidents/MVM is (accidents x 1,000,000)/(VMT x 365).

Intersection	1981	1982	1983	3 Year Average
Needham Street at:				
Winchester Street	23	15	15	17.7
Columbia Avenue	3	5	4	4.0
Jaconnet Street	1	3	1	1.7
Tower Road	7	2	2	3.7
Industrial Place	0	0	0	0.0
Charlemont Street	3	4	3	3.3
Marshall's Plaza	0*	14*	12*	15.3
Oak Street & Christina Street	28	20	15	21.0
Intersection Total	85	63	52	66.7
Mid-block	66	88	97	83.7
Total	151	151	149	150.0
Centre Street at Boylston Street (Route 9)	19	13	6	12.7
Winchester Street at Boylston Street (Route 9)	11	5	6	7.3

*At either 275 Needham or Marshall's Mall.

Highland Avenue/ Needham Street Traffic Analysis	1981-1983 NEWTON POLICE DEPARTMENT ACCIDENT-RECORDS SUMMARY	CTPS
Technical Report 56a August 1986		TABLE 6-2

Intersection	1981	1982	1983	3-Year Average
Highland Avenue at:				
Webster Street	16	16	10	14.0
Cross Street	2	2	1	1.7
Mills Road	0	0	1	0.3
Utica Road	0	1	1	0.7
Gould Street & Hunting Road	18	15	24	17.7
Route 128	14	11	9	11.3
First Avenue	11	6	6	7.7
Wexford Street	22	29	24	25.0
Charles Street	5	2	4	3.7
Second Avenue	20	18	15	17.7
Highland Circle	2	3	1	2.0
Highland Terrace	1	2	1	1.3
Riverside Avenue	2	2	1	1.7
Intersection Total	113	107	98	106.0
Mid-block	22	19	21	20.7
Kendrick Street at:				
Hunting Road &/or Greendale Avenue	3	8	12	7.7
Third Avenue	3	6	3	4.0
Fourth Avenue	2	5	9	5.3
Unidentified	7	1	4	4.0
Totals:				
Highland Avenue	135	126	115	125.3
Kendrick Street	15	20	28	21.0

Highland Avenue/ Needham Street Traffic Analysis	1981-1983 NEEDHAM POLICE DEPARTMENT ACCIDENT-RECORDS SUMMARY	CTPS
Technical Report 56a August 1986		TABLE 6-3

For the three highest-volume thoroughfares in the study area, Needham Street, Highland Avenue, and Kendrick Street, the average accident rate for the three-year period ending in 1983 was:

TABLE 6-4

Estimate of Average Annual Accidents/MVM

<u>Location</u>	<u>VMT</u>	<u>Accidents</u>	<u>Accidents/MVM</u>
Needham Street	21,717	150.0	18.9
Highland Avenue	36,175	125.3	9.5
Kendrick Street	16,281	21.0	3.5.

Comprehensive records kept by the MDPW for the 10 years through 1980 indicate that highways with similar functions average approximately 5.0 accidents/MVM. Furthermore, statewide accident rates for these highway types generally are not found to exceed 8.0/MVM in a single year. In comparison, the excessive rates on Needham Street (18.9) and Highland Avenue (9.5) indicate an apparent safety problem. On the other hand, travel conditions on Kendrick Street are relatively safe by these measures.

6.3 INTERSECTION-SAFETY ANALYSIS

To further specify the kinds of safety problems which may exist, intersection accident characteristics are examined. The number of accidents per one million approach vehicles (accidents/MAV) is used to gauge performance.¹ Intersection safety is generally considered to be poor if the rate exceeds 1.0.

In Table 6-5 a summary of accidents/MAV is presented for each of the major intersections on Needham Street, Highland Avenue, and Kendrick Street. The results provide further explanation of the accident problems which are indicated on Needham Street and Highland Avenue.

First, as pointed out earlier, Highland Avenue has a high density of intersections per mile. The implication of this condition and the high intersection accident rate at several locations is that intersection safety problems contribute heavily to the high accident rate experienced overall.

Needham Street on the other hand has fewer intersections per mile and fewer intersections with poor safety performance.

¹The formula to derive accidents/MAV is (accidents x 1,000,000)/(intersection approach volume x 365)

Highland Avenue at:

Wexford Street	1.93
Webster Street	1.43
Second Avenue	1.30
Gould Street & Hunting Road	1.30
First Avenue	.80
Charles Street	.30
Highland Circle	.20
Riverside Street	.17
Highland Terrace	.13

Needham Street at:

Christina Street & Oak Street	1.80
Winchester Street & Dedham Street	1.63
Columbia Raod & McDonald's	.95
Tower Road	.36
Charlemont Street	.32
Jaconnet Street	.18

Kendrick Street at:

Hunting Road	.69
Third Avenue	.68
Fourth Avenue	.68

Highland Avenue/ Needham Street Traffic Analysis	SUMMARY OF ACCIDENTS PER MILLION APPROACH VEHICLES	CTPS
Technical Report 56a August 1986		TABLE 6-5

Consequently, intersection safety can not be considered the leading factor in the excessively high overall accident rate found. Rather, these results support the argument that mid-block conditions are primarily responsible for the severe safety problems on Needham Street.

This conclusion is consistent with the accident statistics reported in Table 6-2. Inspection of the number of mid-block accidents shows that on Highland Avenue mid-block accidents account for only 16.5 percent of the annual total, on average, whereas on Needham Street mid-block accidents typically account for 55.8 percent. This finding suggests that treatments other than intersection upgrading may be required to properly correct the problems.

6.4 PEDESTRIAN TRAFFIC

The issue of pedestrian safety is one that has been raised by residents of study-area neighborhoods in conjunction with discussions held to find solutions to area traffic problems. Concerns center on the need for pedestrian-crossing facilities, particularly on Needham Street between Christina Street and Winchester Street. Residents cite a lack of crosswalks and signals along Needham Street which makes street crossings extremely difficult and unsafe.

The perception of a need to install pedestrian facilities is not, however, well supported by the pedestrian-crossing volumes recorded as part of the turning-movement counts completed in September of 1984. Pedestrian traffic is highest midday between 12:00 and 1:00 PM and is most concentrated at:

Winchester St. and Dedham St. at Needham St.	17 pedestrians per hour
Tower Rd. at Needham St.	107 pedestrians per hour
Oak St. and Christina St. at Needham St.	54 pedestrians per hour

Warrants for traffic-signal installation and other vehicle-control measures are contained in the Manual on Uniform Traffic Control Devices (MUTCD).¹ The MUTCD warrants specify minimum traffic volumes (vehicular and pedestrian) required to install new or maintain existing traffic signals. The warrant for pedestrian volume is satisfied when:

¹Federal Highway Administration, Manual on Uniform Traffic Control Devices, U.S. Department of Transportation, 1978.

- o 600 or more vehicles per hour pass on the main street during any eight hours of an average day; and
- o 150 or more pedestrians per hour cross on the highest volume crosswalk of the main street during the same eight hours.

Conditions at the three Needham Street intersections do not presently satisfy minimum pedestrian warrant requirements. However, it is unclear whether existing pedestrian volumes are artificially low due to the extremely high traffic volumes with which pedestrians must contend. While it is difficult to assess the extent to which pedestrian trips are not made to and from destinations on Needham Street, it is reasonable to expect that since peak pedestrian volumes are insufficient to meet even one hour of the eight-hour requirement, it is unreasonable to expect sufficient response to the installation of crossing facilities to satisfy the eight-hour warrant.

7 LEVEL OF SERVICE

7.1 INTRODUCTION

The phrase "level of service" is used in this chapter as a qualitative measure of the travel characteristics associated with a specific intersection or road segment. The practice of describing functional characteristics according to a level of service is an attempt to account for the speed, travel time, traffic interruptions, maneuverability, safety, driving comfort and convenience, and operating costs associated with the facility. The maximum volume of vehicles which can be accommodated by a facility at a particular level of service is termed service volume.

Levels of service are ranked A through F. Level of service A is the highest quality of service a highway element can provide. It is a condition of free flow in which the presence of other vehicles does not restrict speed or maneuverability. Level of service B describes a stable-flow condition in which operating speed is sometimes influenced by the presence of other vehicles. Level of service C is also a condition of stable flow; however, individual drivers' freedom to select speeds and maneuver into different lanes becomes restricted. At level of service D, vehicle-operating conditions begin to become unstable. Operating speed is generally tolerable, but considerable and sudden variations occur. At intersections, long delays are common. Level of service E describes the upper limit of operating capacity. Operations at this level of service are unstable, and speeds between two points will fluctuate widely. Traffic densities are high, maneuverability is greatly limited, and the potential for accidents is relatively high. Level of service F describes a condition where speed and rate of flow drop below level of service E when peak demands are present. Density of vehicles is higher than that associated with level of service E and traffic movements fall into a stop-and-go pattern. Intersection delays are excessive and the potential for vehicle conflicts is highest.

The use of level-of-service labels A through F is intended to permit the discussion of the operating characteristics of specific facilities to take place on common ground. The current state of the art does not provide precise definitions of the boundaries between service levels, but rather provides an indication of how well facilities can be expected to perform under various volumes of traffic. The levels of service assigned below

should be considered in this light, and it should be kept in mind that the analysis is limited by the current state of the understanding of traffic-flow phenomena.

7.2 PRESENT OPERATION - CORRIDOR SEGMENTS

Major thoroughfares in the study area, such as Highland Avenue, Needham Street, Kendrick Street and Winchester Street, all fall under the general descriptive heading of urban arterial. Traffic flows on urban arterials are often interrupted by the presence of frequent intersections, commercial driveways, pedestrians, curbside parking and the like. The friction caused by these activities combines with dense roadside development to characteristically hold speed limits--and actual operating speeds--to less than 35 mph.

Closely spaced intersections (greater than one intersection per mile) are a common feature of arterial roadways in an urban setting that is particularly important in determining level of service, since intersection capacity is usually the practical determinant of arterial capacity. This condition exists since the crossing of traffic streams at an intersection is often the most significant impediment to the free flow of traffic on the arterial. Where signalized intersections are present, the interrelationship between adjacent intersections will set the maximum possible flow rate when traffic volume is less than available intersection capacity. Therefore, unless intersection capacity and signal-coordination schemes provide for higher service volumes than the arterial, little or no improvement in traffic flow can be expected from capacity improvements to an arterial.

Arterials in the study area are subject to significant secondary factors, in addition to frequent intersections, which can affect capacity. For instance, Highland Avenue east of Route 128 and Needham Street in Newton both have numerous commercial driveways and minor intersections on either side. Fully 40 percent of the roadside is curb-cut. Right and left turns into and from the driveways reduce the practical capacity of the road by introducing conflict into major-street flows.

To first determine whether corridor capacity is controlled by the roadway lane configuration or by intersection capacity, arterial service volumes were developed for selected locations, as shown in Table 7-1. The adjusted service volumes at level of service E (SV_E) represent the number of vehicles which can be serviced by the facility per hour. At each location, the effects of any nearby commercial driveways and/or minor intersections on capacity have been excluded. The comparison of actual peak directional volume to capacity indicates the existence of sufficient capacity on each facility to service existing traffic demands throughout the day.

		<u>Needham Street East of Tower Road</u>	<u>Highland Avenue Bridge</u>	<u>Highland Avenue East of Second Ave.</u>	<u>Kendrick Street East of Route 128 Bridge</u>
Service Volume at Level of Service E (SV _e)		2000	2000	2000	2000
Number of Lanes		1	1	1	1
Width Adjustment*		1.00	.93	1.00	1.00
Truck Adjustment**	AM	.95	.97	.97	1.00
	PM	.97	.97	.97	1.00
Adjusted SV _e		1900	1804	1984	2000
		PM	1804	1940	2000
Actual Volume	AM	966	1193	1247	1701
	PM	1108	1083	1071	1399
*Surface Width		36'	29'	42'	40'
Total Number of Lanes		<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>
Width per Lane		18'	14.5'	21'	20'
Lane Width for Reduc- tion Adjustment		<u>12'</u>	<u>12'</u>	<u>12'</u>	<u>12'</u>
Distance from Traffic- Lane Edge to Obstruc- tion		6'	2.5'	9'	8'
Adjustment Factor (ITE Table 16-14)		1.00	.93	1.00	1.00
**Truck % (Peak Direction)	AM	EB 5.59	EB 3.94	EB 3.11	EB 0.82
	PM	EB 1.07	WB 2.52	WB 1.59	WB 0.00
Adjustment Factor for Trucks (ITE Table 16-15)	AM	.95	.97	.97	1.00
	PM	.97	.97	.97	1.00

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UNINTERRUPTED-FLOW CAPACITY
OF SELECTED
STUDY-AREA ROADWAY SEGMENTS

CTPS

TABLE

7-1

Study-area intersection performance is evaluated in section 7.4 of this report and summarized in Table 7-2. Review of the analytic results contained in Table 7-2 indicate the presence of poorly functioning intersections on:

- o Kendrick Street: Third Avenue and Fourth Avenue
- o Highland Avenue: Second Avenue and Webster Street
- o Needham Street: Oak Street and Christina Street,
Winchester Street
- o Winchester Street: Route 9 ramps

Clearly, the conflicts created in the major traffic flows by these intersections cause more frequent interruption of flow than does the lane-configuration of the connecting segments, since all segments function at better than level of service E, as shown in Table 7-1.

Service volume on certain of these arterials is, however, affected by a significant number of minor intersections and commercial driveways, which affect capacity as would an unsignalized intersection. To estimate and compare the effect of commercial driveways and intersecting streets on traffic flow, the Needham Street/Tower Road intersection was selected, as representative of typical conditions. To compare performance, reference is again made to Table 7-2. Under peak-load conditions, Tower Road traffic conflicts with heavy flows of traffic on Needham Street and encounters delays typical of level of service E operating conditions. In comparison with the major intersections on Needham Street and Highland Avenue, minor locations such as Tower Road tend to perform better and have slightly less impact on major street traffic.

On the basis of these findings, arterial performance within the study area appears to be adversely affected to the greatest extent by major signalized and high-volume unsignalized intersections. Traffic flows are also interrupted by operations at minor intersections and commercial drives which are forced to compete for space in major street flows or be delayed for long periods.

In summary, the simple comparison made here between analyses indicates that present lane configurations are sufficient to serve peak-demand traffic volumes occurring in the study area. Delays which occur on certain road segments result from downstream factors such as major intersections which cannot service the same level of throughput as the feeder arterial.

7.3 HIGHLAND AVENUE BRIDGE

Highland Avenue Bridge spans the Charles River and the Newton-Needham line where Highland Avenue meets Needham Street.

	L O S		
	AM	MID	PM
Nahanton St @ Wells Ave:			
Left Turns from Nahanton St to Wells Ave	C	A	A
Left Turns from Nahanton St to Jewish Comm Campus	A	A	A
Left Turns from Wells Ave to Nahanton Street	F	F	F
Left Turns from Jewish Comm Campus to Nahanton St	F	D	F
Kendrick St @ Fourth Ave:			
Left Turns from Kendrick St to Fourth Ave	A	A	A
Left Turns from Fourth Ave to Kendrick St	F	D	F
Kendrick St @ Third Ave:			
Left Turns from Kendrick St to Third Ave	A	A	A
Left Turns from Third Ave to Kendrick St	F	C	E
Kendrick St @ Hunting Road:			
Left turn check failure: Hunting Rd SB to Kendrick Street EB			
Signalized Intersection--Overall Summary	E	A	B
Kendrick St @ Greendale Ave:			
Left Turns from Greendale Ave to Kendrick St EB	B	A	A
Left Turns from Kendrick St to Greendale Ave SB	A	A	A
Webster St @ Greendale Ave:			
Left Turns from Webster St SB to Greendale Ave SB	A	A	A
Left Turns from Greendale Ave NB to Webster St SB	A	A	A
Webster St @ Highland Ave:			
Left-turn check failure: Highland Ave WB to Webster St			
Signalized Intersection--Overall Summary	A	A	C
Highland Ave @ Gould St & Hunting Road:			
Left-turn check failure: Gould St to Highland Ave EB			
Signalized Intersection--Overall Summary	C	B	D
Highland Ave @ Wexford St:			
Left Turns from Highland Ave to Wexford St	E	C	E
Left Turns from Wexford St to Highland Ave	F	F	F
Highland Ave @ First Ave:			
(NO LEFT-TURN CONFLICT)			
Highland Ave @ Second Ave:			
Left-turn check failure: Second Ave to Highland Ave*			
Signalized Intersection--Overall Summary	C	C	F

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EXISTING CONDITIONS
INTERSECTION PERFORMANCE
SUMMARY

CTPS

TABLE

7-2a

Needham St @ Oak St & Christina St:

Left Turns from Needham St to Oak St
 Left Turns from Needham St to Christina St
 Left Turns from Oak St to Needham St
 Left Turns from Christina St to Needham St

B	B	A
A	B	B
F	F	F
F	F	F

Needham St @ Tower Road:

Left Turns from Needham St to Tower Road
 Left Turns from Tower Rd to Needham St

A	B	A
E	E	E

Winchester St @ Route 9 Ramps EB:

Left Turns from Winchester St to EB Ramp
 Left Turns from EB Ramp to Winchester St

B	B	E
F	F	F

Centre St @ Route 9 Ramps & Winchester St:

Left Turns from Winchester St to Rte 9 WB
 Left Turns from Rte 9 WB off-ramp
 Left Turns from Rte 9 on-ramp

D	B	C
F	F	F
F	E	E

Needham St @ Winchester St & Dedham St:

Left Turns from Needham St
 Left Turns from Dedham St
 Left Turns from Winchester St NB
 Left Turns from Winchester St SB

D	C	E
A	A	A
F	F	F
F	F	F

*Unopposed movement - theoretical result

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EXISTING CONDITIONS
 INTERSECTION PERFORMANCE
 SUMMARY

CTPS

TABLE

7-2b

Under its present configuration the bridge is the narrowest point of the corridor. Bordered by curbed, five-foot sidewalks on either side, the surface of the the bridge is split equally into two 14.5-foot lanes.

The bridge is perceived as a constraint to smooth traffic flow along this segment of the corridor due to the narrowed approaches and the presence of vehicles queued across its length during peak periods. To the west, on the Needham side of the bridge, the road surface narrows from 42 feet at Second Avenue to 29 feet at the bridge approach. Eastbound traffic enters this road segment as two lanes of traffic. The distance available for merging into a single lane is approximately 750 feet.

Approaching the bridge on the Newton side, traffic experiences a smaller change in road-surface width. The surface is 30-feet wide at the Needham Street/Oak Street intersection approximately 290 feet to the east of the bridge. Westbound vehicles from the Oak Street intersection enter the bridge approach in a single lane of traffic into which no merging will occur prior to crossing the river.

The potential for congestion and delay on approaching the bridge consequently exists only on the westerly merge in the eastbound traffic stream. To evaluate the potential for delay, determination of practical service volume (SV_e --maximum capacity, or the volume that can be serviced by a roadway segment at level of service E) is necessary. The determinants of service volume most pertinent to merge sections include sight distance, speed, angle of convergence, and grade. Under ideal conditions, the merge volumes can often approach the SV_e of adjacent arterial sections.

The two lanes of eastbound traffic on Highland Avenue exit the Second Avenue intersection at nearly equal speed on a nearly level surface. Sight distance is ample and the amount of maneuvering required to merge is minimal. Under these conditions, the merge SV_e should approach the free-flow rate of 2000 vehicles per hour (VPH) at level of service E. Adjusting the free-flow rate according to the traffic-mix percentages and width-reduction factors used in the bridge evaluation in Table 7-1 gives the SV_e of 1800 VPH.

Eastbound traffic flows peak during the morning period, when volumes reach approximately 1,250 VPH. Following the same procedure of comparing demand (1,250) to capacity (1,800) as done previously in Table 7-1, sufficient capacity clearly exists on the merge section to accommodate current demand. The merge segment is, therefore, not the cause of traffic delay or congestion problems west of the bridge. Furthermore, the data contained in Table 7-1 with respect to the bridge itself indicate sufficient capacity (1804) on the bridge surface to service peak traffic demands (1250). Therefore, neither the narrowness of the bridge nor the merging on the approach legs can be considered a cause of the queuing problems periodically apparent.

The extensive vehicle queuing which is present on both approaches to the bridge and on either side of the bridge deck during peak hours occurs in response to capacity limitations at the intersections on either end. Westbound traffic queues are most extensive when operations at the Highland Avenue/Second Avenue intersection are most severely strained, typically during the PM peak. During the morning and midday periods, westbound movements through the intersection are more stable, and queuing does not extend to the bridge nor is westbound movement across the bridge impeded.

Eastbound volume across the bridge is higher in the morning than in the evening. Traffic queues forming at the Needham Street/Oak Street intersection are, however, more extensive during the evening, when intersection operations are under stress. Eastbound movements across the bridge are subject to delays which are dependent on the operating condition of this intersection.

There is, therefore, no purpose at present in providing more capacity on the bridge than currently exists. Intersection capacity must first be brought to parity with the bridge section. To provide equal amounts of capacity at intersections and road segments, the number of through intersection-approach lanes should be at least double the number of segment lanes. The eastbound configuration of Highland Avenue at Second Avenue certifies this operating criterion. The Highland Avenue approach to the Second Avenue intersection is two standard-width (12-foot-plus) lanes. Turning movements at the intersection are a mix of a consistent but small amount of left-turning traffic and an approximately 12-percent demand for right turns onto Second Avenue. Through-moving traffic exits the intersection into two lanes prior to merging into a single lane. The single-lane capacity is sufficient to carry this volume of traffic until impeded by the subsequent Needham Street/Oak Street intersection.

Traffic conflicts at unsignalized intersections and the splitting of green time between phases at signalized intersections significantly reduces the vehicle-per-hour service volume of intersection approach lanes. Assuming a signalized intersection which splits green time evenly (50:50) between crossed streets, lane capacity per hour will be a maximum of 50 percent of its unrestricted hourly service volume. At unsignalized intersections, conflicting cross flows can introduce the same or more substantial reductions in hourly volumes, depending on the volume of traffic and the operating environment. Consequently, the number of intersection approach lanes should be a multiple of corridor through lanes by a factor of two or more to achieve similar levels of capacity.

7.4 PRESENT OPERATION - INTERSECTIONS

Peak operational performance was evaluated for each of the major study-area intersections. To assess operations, use was

made of the Critical Movement Analysis (CMA) techniques published in TRB Circular 212. At each location, morning, midday and evening peak-hour traffic operations were examined. Analysis procedures, assumptions, and findings are presented in detail in Appendix D.

Roadway and traffic data used in the analysis were gathered by site inspection and turning-movement counts conducted in the summer and fall of 1983. On the basis of this information, peak-hour traffic characteristics were determined for each location.

For analysis of signalized intersections, the CMA Operations and Design technique was employed. The base assumption of this approach is that there is a combination of lane volumes which must be accommodated through the middle of a signalized intersection within one hour. The sum of these volumes cannot exceed a predetermined saturation flow level characteristic of the intersection.

The Operations and Design approach involves the specification of detailed information as to roadway geometrics and traffic characteristics. Specifically, data describing vehicle mix, traffic-peaking characteristics, turning movements, lane use, and lane width are required to adjust actual hourly volume totals. This adjustment of vehicles per hour into passenger-car equivalents per hour permits the most accurate possible depiction of intersection operations.

For analysis of unsignalized intersections, the CMA Unsignalized Intersection method was applied. The key assumption of this procedure is that major-street traffic is not affected by minor-street movements. Vehicle flows are converted into passenger-car equivalents per hour on the basis of approach grade and vehicle mix, and the maximum flow of vehicles is calculated for each minor-approach movement. Demand is then compared to capacity for each movement and the probable delay and level of service are estimated. A level of service which reflects delay is derived for:

1. right turns onto the major road;
2. left turns from the major road;
3. through traffic crossing the major road; and
4. left turns onto the major road.

The findings of the intersection-performance evaluation are summarized in Table 7-2. Turning-movement-count sheets and level-of-service worksheets are in Appendix D. Overall, 12 of the 16 intersections examined experience excessive delay on one or more approaches. An explanation of the findings and of the factors causing poor performance are outlined below.

Nahanton Street at Wells Avenue (unsignalized)

Nahanton Street traffic flows are heaviest during the morning period. This heavy volume of through and turning traffic blocks the relatively minor volumes of side-street traffic exiting Wells Avenue and the Jewish Community Campus. During the midday and evening periods, traffic flows from Wells Avenue and the Jewish Community Campus increase. At the same time, Nahanton Street traffic is lower, creating greater capacity for left turns from each of the minor-street approaches. However, increased levels of left-turn demand from Wells Avenue during both the mid-day and the evening periods and from the Jewish Community Campus approach during the evening peak exceed the Nahanton Street capacity. Left turns from the minor streets, therefore, experience excessive delays during those periods of the day.

Kendrick Street at Fourth Avenue (unsignalized)

Third Avenue and Fourth Avenue together function as the southern entrance/exit to the New England Industrial Center (NEIC), with Fourth Avenue generally carrying more traffic in the northerly, inbound direction. Analysis of Fourth Avenue demand indicates that left-turning traffic from this approach suffers excessive delay during the morning and evening peak periods due to high volumes of Kendrick Street traffic. However, on-site observation of traffic operations indicates better performance than anticipated from analysis. Ample sight distance and lane widths on Kendrick Street allow traffic entering from Fourth Avenue to minimize acceptable gap times between vehicles on Kendrick Street and enter the flow without disruption to through traffic flows.

Kendrick Street at Third Avenue (unsignalized)

The morning peak demand of traffic exiting the NEIC at Third Avenue is similar in magnitude to that of Fourth Avenue. Total traffic on Kendrick Street is also almost identical to the AM volume at Fourth Avenue (approximately 2100 VPH). Consequently, the analysis indicates excessive delay for left-turn traffic emanating from Third Avenue during the morning.

The physical layout and environment of the intersection is also very similar to the adjacent Fourth Avenue intersection, in that it provides ample sight distance and sufficient lane widths to permit traffic entering the Kendrick Street traffic stream to minimize acceptable gap time and merge onto Kendrick Street without excessive delay. The delays which do affect traffic exiting the NEIC at Third and Fourth are caused primarily by traffic on the near-side westbound lane. Once acceptable gaps are found in these flows, most left-turning vehicles are able to cross into the eastbound lane since continuous eastbound traffic has sufficient space to maneuver around the slower merging traffic. Consequently, average delay is less than would be expected under more typical operating conditions.

Kendrick Street at Hunting Road (signalized)

High volumes of southbound Hunting Road traffic turning left onto Kendrick Street cause low levels of service and long delays to occur periodically within the morning peak hours. Observation of peak-hour operations indicates the presence of a few isolated instances of cycle failure which are absent at other times of the day (cycle failure occurs when sufficient green-phase time is not available to clear the standing queue of vehicles).

Highland Avenue at Webster Street (signalized)

Left turns from Highland Avenue westbound to Webster Street peak during the evening. This high volume of left turns conflicts with peak-hour eastbound through and right-turn movements on Highland Avenue, causing excessive delay. Cycle failure occurs only sporadically during the evening peak hour and is not a problem during morning or midday times.

Highland Avenue at First Avenue (unsignalized)

The north side of the NEIC is served by two entrance/exit facilities; First Avenue services primarily entering traffic and Second Avenue serves as the principal exit. This is due to the closer proximity of First Avenue to Route 128 (a significant generator of trips to the NEIC) and to the left-turn prohibition at the Highland Avenue/First Avenue intersection. As a consequence, traffic demands appear as high inbound/southbound traffic volumes on First Avenue and high outbound/northbound volumes on Second Avenue. The fact that all left turns to-and-from First Avenue at Highland Avenue are prohibited eliminates the major traffic conflicts which could occur here. As a result, right-turn traffic presents the only possible conflict, and the analysis showed that this movement operates without excessive delay throughout the day.

Highland Avenue at Wexford Street (unsignalized)

Consistently high volumes of through traffic across four lanes cause significant blockage of left turns from Wexford Street throughout the day. Conditions are most severe during the evening peak hour, when total intersection traffic is highest.

Highland Avenue at Second Avenue (signalized)

As mentioned above, Second Avenue functions in conjunction with First Avenue as a north-side entrance/exit pair of the NEIC. Due to left-turn restrictions on traffic exiting First Avenue, Second Avenue serves as the primary north-side exit. Traffic leaving the NEIC on Second Avenue and traffic headed in the direction of Route 128 on Highland Avenue combine to create an extremely high westbound demand at this intersection during the PM peak. Cycle failure occurs as westbound traffic is inter-

rupted by left turns being made into and out of both Charles Street and Wexford Street. When interrupted, the dense traffic flows quickly form queues which often extend to the east beyond the Highland Avenue Bridge. The potential for prolonged periods of congestion is present since the peak demand levels exceed the available capacity and these operating problems are compounded by the downstream (Charles Street and Wexford Street) disruptions.

Needham Street at Oak Street and Christina Street (unsignalized)

Left turns from Oak Street and Christina Street experience excessive delay throughout the day. While left-turn volume from each minor street is relatively low, Needham Street flows are consistently high enough during each peak to restrict minor-street movements. The situation is often worsened during the evening when traffic queues from the Second Avenue/Highland Avenue intersection become extensive enough to interfere with the westbound flow of vehicles on Needham Street and further reduce the flow out of Oak Street and Christina Street.

Needham Street at Tower Road (unsignalized)

The Needham Street/Tower Road intersection was selected as being representative of the minor three-legged intersections found throughout the Highland Avenue/Needham Street corridor. Peak-hour traffic volumes are low, less than 150 VPH; nonetheless, continuously high volumes of traffic on Highland Avenue and Needham Street during peak periods and throughout the day cause minor-street left turns to be subject to very long delays.

This condition is typical of many intersections and drive-ways along Needham Street. Vehicle queues do not tend to be extensive (2 or 3 vehicles during peak periods), since most approach widths are sufficient to accommodate separate left- and right-turn queues and thus permit right-turn movements to exit unimpeded by delayed lefts.

Needham Street at Winchester Street and Dedham Street (unsignalized)

Traffic patterns at this location are complicated by the movement of the majority of traffic across an oblique angle formed by the Needham Street and Winchester Street (north) approach legs. Specifically, between 80 and 85 percent of the Needham Street traffic moves through the intersection as a left turn onto Winchester Street northbound. On Winchester Street, a right turn onto Needham Street is made by between 68 and 75 percent of the Winchester Street southbound traffic. To evaluate the intersection, the assumption was made that Needham Street and Dedham Street function together as the major street pair. On this basis, the analysis indicates extreme congestion experienced by:

- o all movement on Winchester Street NB, and
- o lefts and through movements on Winchester Street SB.

The Needham Street left-turn movements onto Winchester Street northbound experience long delays in the morning period, moderate delays midday, and very long delays during the evening.

In this unusual application of the analytical method, it gives priority to the eastbound movements originating on the Dedham Street approach. In fact, operational priority resides with the Needham Street approach, which is under yield control while the Dedham Street approach is on stop control. Therefore, the delay and level-of-service findings for the Needham Street left turn and the Dedham Street approach should be reversed. Under this assumption, Dedham Street traffic operates at level of service E during the PM.

Winchester Street at Route 9 Eastbound On/Off Ramp (unsignalized)

Turning movements from the Route 9 on/off ramp fail at peak periods throughout the day. The analysis indicates that the problem is related to traffic volumes on Winchester Street and the shared use of a single off lane on the ramp by left- and right-turning traffic.

The problem is compounded by the geometric configuration of the ramp approach to the intersection, including the stop-line placement, and the alignment of the Winchester Street approach south of the intersection, which places severe limitations on sight distances from the the ramp.

In addition, during evening peak hours left turns from Winchester Street onto the ramp experience very long delays and queue in the path of vehicles preparing to turn left onto Winchester Street from the ramp. This often results in hazardous attempts by motorists to circumvent the congestion by traveling off assigned paths.

Centre Street/Winchester Street at Route 9 Westbound On/Off Ramps (unsignalized)

Traffic volumes exiting the westbound on-off ramp are low throughout the day. During the morning peak period the analysis indicates failure for left turns from this direction. This problem arises from the high volume of traffic on Centre Street and the queuing of Winchester Street vehicles waiting to turn left onto the ramp.

Confusion exists among motorists exiting the ramp who must contend with the large raised island positioned at the foot of the ramp. The island is placed to separate traffic moving on from traffic moving off the ramp. However, no provision is made

in the present configuration for left turns from the ramp onto Centre Street eastbound. Consequently, motorists who wish to make this turn can find it difficult to decide which side of the island to position themselves on prior to moving into the intersection. Although the peak-hour demand for this movement is nominal, these vehicles have a presence in the intersection which significantly complicates the operating environment.

Traffic from Winchester Street wishing to turn left onto the ramp is subject to long delays in the morning and moderate delays in the evening. It often conflicts with the heavy volume of westbound traffic on Centre Street and at times with left turns from the ramp.

8 ALTERNATIVE CONFIGURATIONS

8.1 HIGHLAND AVENUE/NEEDHAM STREET

The preceding analysis clearly indicates that most trips on Highland Avenue and Needham Street between Route 128 and Route 9 are likely to encounter substantial delays and hazardous conditions. The accident rate is considerably higher than on other road segments within the study area and is also high in comparison to statewide rates for similar facilities. Several problem sources have been identified:

- o several major high-volume intersections;
- o numerous curb cuts; and
- o roadside developments which attract traffic from all directions.

To address the problems along Highland Avenue and Needham Street, the "Highland Avenue/Needham Street Corridor Consensus Plan" recommends reconfiguration of the corridor into a five-lane cross-section between approximately First Avenue in Needham and the Winchester Street/Dedham Street intersection in Newton. The middle or fifth lane would be a continuous two-way left-turn median lane (CTWLTML), which vehicles would enter immediately prior to where the intended left turn would be made and wait for an appropriate gap in the opposing traffic stream. The four remaining lanes would be used to carry through traffic, which would benefit by the elimination of left-turn queues from the through lanes.

To assess the effectiveness of the five-lane alternative, an extensive review of the current literature was conducted. The findings of this research are summarized in an internal CTPS memorandum dated August 10, 1984 and contained in Appendix E. The primary concern in the consideration of a CTWLTML is the nature of existing traffic demands. Areas which appear to benefit most are, typically, either dense residential areas or commercial strip developments. An extensive number of curb cuts is a common trait. Traffic volumes are usually moderate (between 8,000 and 30,000 ADT), and a continuous demand for left turns is present throughout. Within this environment, the CTWLTML can effect:

- o a decline in total accidents;
- o improved traffic flow; and
- o improved access to local abutting properties.

The application of a CTWLTML is most appropriate in areas where access to adjacent land use is unrestricted and where future land-use activities will continue to require unlimited mid-block accessibility. Depending upon an area's accident history and whether curb-cut consolidation is possible and desirable, other lane treatments may offer greater utility and practicality. On sections where conflicts arise primarily from driveway operations, several design improvements can be implemented to minimize the occurrence of conflicts:

- o consolidate driveway openings;
- o control spacing between adjacent driveways;
- o provide one-way operation where inner circulation is available;
- o provide acceleration and deceleration lanes;
- o install left-turn bays on the arterial roadway at high-volume driveways.

In especially dense commercial areas such as the Highland Avenue/Needham Street corridor, driveway-spacing requirements and acceleration-deceleration lanes are largely inappropriate due to the constraints imposed by the proximity of individual land-use activities requiring direct access. The installation of mid-block left-turn bays would be similarly insufficient to accommodate the consistent level of left-turn demands along corridor segments. Driveway consolidation and internal one-way circulation would, however, offer some operational improvement by minimizing the frequency of conflict along the corridor.

8.1.1 Needham Street

In recommending a five-lane configuration, the Consensus Plan recognizes the value of encouraging actions such as curb-cut consolidation, while emphasizing the area-wide need for immediate access to local properties and for additional through traffic capacity. On the Needham Street portion of the corridor, the land-use diversity, extensive curb cuts, and high traffic volumes are characteristic of the type of commercial strip which is suitable for CTWLTML treatments. Observation of traffic activity indicates a continuous pattern of left-turn movements occurring throughout Needham Street. Vehicles queue for left turns on the far left side of the lane, allowing through traffic to maneuver past. In certain locations, road width and vehicle positioning do not permit through traffic enough maneuvering space, and blockages occur. Installation of a CTWLTML would introduce

greater control over vehicle-queuing procedures and permit fewer interruptions of through traffic.

The analysis of corridor capacity discussed in the preceding section does not, however, support the need for the addition of two through lanes on Needham Street. Vehicle flow on Needham Street is presently constrained to the greatest extent by capacity limitations at intersections and driveways. As a general principle, the number of approach lanes provided for through movements at major intersections should number at least twice that of the feeding arterial. However, a three-lane treatment comprising two through lanes and a CTWLTML is sufficient to satisfy existing demand.

8.1.2 Highland Avenue

To the west of Highland Avenue Bridge, land-use diversity and extensive curb cuts exist on both sides of Highland Avenue as far west as Second Avenue. Travel demands on this segment, however, differ markedly from those found on Needham Street. Total left turns between Highland Terrace and the bridge were surveyed as part of the CTPS turning-movement counts taken in September 1984. Only one to three percent of all traffic (eastbound and westbound) turns left. During the same time period (2:15 PM-3:15 PM) on the same day, left turns at the Marshall's Plaza entrances on Needham Street were also surveyed, and it was found that between six and eight percent of the eastbound traffic alone passing each entrance turned left into the plaza. Directional traffic volumes were of similar magnitude for the Highland Avenue and Marshall's Plaza counts: 848 and 992, respectively.

The different Highland Avenue traffic patterns can be explained in part by the absence of a major trip generator such as Marshall's Plaza. In fact, the parcels neighboring Marshall's Plaza on Needham Street contain several major trip generators/ attractors, including Baybank Middlesex, Federal Express, Dimensions, and Papa Gino's. Each of these establishments and those further east create a continuous day-long demand for left turns on the Newton side of the corridor. The lack of similar-scale trip generators between the bridge and Second Avenue greatly diminish the utility potential of a CTWLTML treatment in Needham.

Immediately west of Second Avenue, Highland Avenue is a four-lane facility. Left-turn demand on this segment is predominantly focused at the intersections of Charles Street and Wexford Street. High volumes of through traffic in all four lanes make left-turn movements into and from these intersections extremely difficult and unsafe. Conditions are worst at the Wexford Street intersection, where between 10 and 15 percent of eastbound Highland Avenue traffic turns left, depending on the time of day. The intersection has the worst accident history in the study

area, with a three-year annual average of 1.92 accidents per million approach vehicles for the years 1981 to 1983. Left turns from Wexford Street encounter extremely long delays in attempting to access Highland Avenue. The delay is caused in part by the inherent difficulty of crossing into four lanes of traffic and by the high volume of traffic passing Wexford Street and blocking movements onto Highland Avenue.

To address problems on this segment of the corridor, the Consensus Plan calls for opening the median barrier at First Avenue, installing a signal, and initiating a five-lane cross-section to the east. The median opening and signal are intended to improve access to Route 128 and points west from the NEIC and eliminate illegitimate U-turns and left turns being made into Wexford Street from First Avenue.

Reopening the median barrier at First Avenue and signaling the intersection would be of particular benefit to traffic originating in the NEIC with destinations to the west on Highland Avenue or north/south on Route 128. In addition, it would improve westbound flow on Highland Avenue between Second Avenue and First Avenue by:

- o Minimizing turn conflicts at the Highland Avenue/Wexford Street intersection. Opening the median would eliminate the need of First Avenue traffic to use Wexford Street to reverse direction on Highland Avenue.
- o Diverting traffic exiting the NEIC at Second Avenue to First Avenue, which would reduce the volumes of westbound traffic on the segment.

Reopening the median under present conditions would also carry with it, however, unacceptable adverse impacts on the safety of Route 128 northbound traffic exiting onto Highland Avenue. Originally installed to prevent unsafe vehicle queues from forming on the exit ramp and extending onto Route 128, the median barrier was intended to eliminate the delays and conflicts associated with the signal at the First Avenue/Highland Avenue intersection. Reopening the median under present conditions would reintroduce the delays and unsafe ramp queue which existed prior to the extension of the median barrier.

Successful signalization and removal of the median at First Avenue requires additional action to divert traffic from the eastbound approach to the intersection. Assuming that enough traffic could be diverted so that the service volume of the intersection equalled the approach volume, signalization could proceed. However, traffic-diversion tactics are generally expensive, build options requiring a lead time which is inappropriate for short-range consideration. Median reopening and signalization of the Highland Avenue/First Avenue intersection is con-

sequently a long-term proposition to be assessed among future scenarios.

Remaining in question is the applicability of a five-lane section on Highland Avenue between First Avenue and Second Avenue. On this segment, demand for immediate roadside access is limited, because of the predominance of office buildings and the absence of retail establishments. The exception is at the Wexford Street intersection, where service stations are located on opposing corners. Left-turn demands from Highland Avenue eastbound flows are concentrated at the Wexford Street and Charles Street intersections. Westbound left-turn demand has in the past been minor, due to the scale of the land-use activity fronting on the south side of Highland Avenue. Present traffic patterns are likely to change rapidly as construction of large-scale developments is completed.

Nevertheless, in both the short and long term, CTWLTML would be used predominantly by eastbound traffic turning left into either Wexford Street or Charles Street. Accommodation of these turns could be more easily accomplished by installation of exclusive left-turn bays at each approach.

Installation of exclusive turn bays does not, however, address the difficulties encountered by First Avenue traffic seeking improved access to Route 128 and points west on Highland Avenue. To permit First Avenue traffic to move westbound on Highland Avenue, a direct connection between First Avenue and Second Avenue between Highland Avenue and Cabot Street may be required. First Avenue traffic could then merge with Second Avenue traffic and access Highland Avenue west without having to turn left or reverse direction on Highland Avenue.

In addition, left turns into Wexford Street or Charles Street could be eliminated if access to the north side of Highland Avenue from the eastbound Highland Avenue direction were routed onto First Avenue and the service-road loop. Several benefits to safety and traffic flow could be expected:

- o Traffic flow east and west on Highland Avenue would benefit from a reduction in cross-traffic conflicts and from the elimination of left-turn queues in a travel lane.
- o Operating conditions would be improved by elimination of the chaotic conditions which arise as attempts are made by First Avenue traffic on Highland Avenue to U turn or reverse direction by first entering Wexford Street.
- o A reduction in rear-end accidents could be expected from the elimination of queues on Highland Avenue. A decline in angle collisions would also be expected as left-turn U-turns into Wexford Street are eliminated.

- o Left-turning traffic from Wexford Street and Charles Street would no longer conflict with left-turn queues on Highland Avenue, and access from Wexford onto Highland Avenue eastbound would be improved.

8.1.3 Summary - Road-Segment Alternatives

On the basis of the preceding discussion, it is clear that installation of a continuous two-way left-turn median lane (CTWLTML) would not significantly benefit traffic between First Avenue and the Highland Avenue Bridge. Opening the median at First Avenue could improve traffic flow on Highland Avenue while providing more direct access to Route 128 and Highland Avenue westbound from the NEIC, but it could also result in the interruption of traffic exiting the Route 128 northbound ramp, thus bringing about unsafe conditions on Route 128. This alternative should be re-evaluated in conjunction with the Frontage Road network alternative that will be discussed in the future-conditions report to be produced in the next phase of this study.

However, the establishment of a direct connection between First Avenue and Second Avenue immediately behind the southside Highland Avenue blockface is an alternative which would offer similar levels of Route 128 access to First Avenue traffic without threatening exit-ramp safety. In addition, eastbound Highland Avenue traffic destined for Wexford or Charles Street could be directed onto this service loop via First Avenue, creating access to Wexford/Charles from Second Avenue. Second Avenue/Highland Avenue intersection operations would benefit by the conversion of difficult downstream left turns (e.g., Highland Avenue EB to Wexford Street) into right turns (e.g., Highland Avenue WB to Wexford Street).

On Highland Avenue Bridge, traffic queues form across the bridge in response to excessive delays at the intersections on either end. Bridge capacity is in excess of current peak-flow volumes; the traffic flows are regulated by the adjacent intersection capacities. Until intersection-capacity improvements have been completed, recommendations for bridge improvements cannot be made.

On Needham Street in Newton, the consistently high level of demand for left turns to access either side of the road makes the area a suitable zone for treatment with a CTWLTML. Under existing traffic volumes, adequate service is possible with a three-lane cross-section of two outside through lanes and a CTWLTML. The three-lane configuration would be continuous for the entire length of Needham Street.

8.2 INTERSECTIONS

Intersection problems have been identified at seven locations on the Highland Avenue/Needham Street corridor between Route 128 and Route 9:

- o Highland Avenue at Wexford Street
- o Highland Avenue at Second Avenue
- o Needham Street at Oak Street and Christina Street
- o Needham Street at Tower Road
- o Needham Street at Winchester Street and Dedham Street
- o Winchester Street at Route 9 eastbound ramp
- o Centre Street at Route 9 westbound ramps

As discussed previously, under present conditions corridor capacity is limited by the service volume capacity of the intersections. Several also have high accident rates which contribute to hazardous operating conditions throughout the corridor. To improve conditions, several alternatives, including signalization, geometric alterations, and additional approach lanes, have been considered to supplement the signal-installation recommendations contained in the Consensus Plan. Level-of-service profiles of specified upgrading at each location are summarized in Table 8-1.

8.2.1 Highland Avenue at Wexford Street

To provide an acceptable operating environment at this intersection, traffic patterns on Highland Avenue and/or Wexford Street require alteration. At present, Highland Avenue traffic volumes are sufficient to effectively use all available intersection capacity. The relatively low level of demand on the Wexford Street approach renders capacity improvements such as the addition of approach lanes impractical. This low-level Wexford Street demand is also insufficient to warrant signal installation. Interruption of Highland Avenue traffic flows to accommodate the minor flows from Wexford Street would result in an overall deterioration in service level at the site.

Short of rerouting traffic or prohibiting left turns from Wexford Street, marginal improvement in current conditions is possible by establishing exclusive left- and right-turn lanes on Wexford. This would ensure unrestricted movement onto Highland Avenue by right-turning vehicles and provide maximum intersection access to left-turning vehicles. Minor land acquisition may be required to provide sufficient width for the additional lane.

For a more permanent resolution of the problems, it may be necessary to implement more drastic measures, which would:

- o eliminate all First Avenue traffic turning left into Wexford Street to reverse direction;
- o eliminate left turns from Wexford Street; and/or
- o eliminate left turns into Wexford Street (and Charles Street).

With the exception of a complete prohibition of all left turns at Wexford Street and Charles Street, there is no combination of

Highland Ave @ Gould St & Hunting Road:
 o NO ACTION NECESSARY

Highland Ave @ First Avenue:
 o NO ACTION NECESSARY

Highland Ave @ Wexford St:

- o Install Exclusive Left/Right Lanes on Wexford St
- Left Turn from Highland Ave to Wexford St
- Left Turn from Wexford St to Highland Ave

Highland Ave @ Second Avenue:

- o Add Exclusive Left-turn Lane to Highland Ave WB
- o Establish Two Exclusive Left-turn Lanes and One Exclusive Right-turn Lane on Highland Ave
- Signalized Intersection--Overall Summary

Needham St @ Oak St & Christina St:

- o Install Signals
- o Install Exclusive Left-turn Lanes on Needham St
- Signalized Intersection--Overall Summary

Needham St @ Tower Road:

- o Install Exclusive Left- & Right-turn Lanes on Tower Road
- Left Turn From Needham St to Tower Rd
- Left Turn From Tower Rd to Needham St

Needham St @ Winchester St & Dedham St:

- o Install Signals
- o Use TOPICS-Recommended Lane Configurations
- Signalized Intersection--Overall Summary

Winchester St @ Rte 9 EB Ramp:

- o Install Signals with Protected Left, Overlap from Winchester St to EB Ramp
- Signalized Intersection--Overall Summary

Centre St & Winchester St @ Rte 9 WB Ramp:

- o Install Signals with Protected Left, Overlap from Winchester St to WB Ramp
- Signalized Intersection--Overall Summary

Nahanton St @ Wells Ave:

- o Install Signals
- o Install Exclusive Left on Nahanton St WB
- o Install Exclusive Right on Nahanton St EB
- Signalized Intersection--Overall Summary

L O S

AM	MID	PM
C	B	D
*	*	*
E	C	E
F	F	F
C	B	C
C	C	D
C	C	D
D	C	C
E	D	D
E	A	E

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PERFORMANCE SUMMARY
 ALTERNATIVE IMPROVEMENTS

CTPS

TABLE

8-1a

Kendrick St @ Fourth Ave:

- o Install Signals w/Exclusive Left/Right on 4th
Signalized Intersection--Overall Summary

C	A	B
---	---	---

Kendrick St @ Third Ave:

- o Install Signals w/Exclusive Left/Right on 3rd
Signalized Intersection--Overall Summary

C	A	C
---	---	---

Nahanton St @ Wells Ave:

- o Install Signal
- o Install Exclusive Left on Nahanton St WB
- o Install Exclusive Right on Nahanton St EB
Signalized Intersection--Overall Summary

E	B	D
---	---	---

Kendrick St @ Fourth Ave:

- o Permit Inbound Movement Only
(Fourth Ave One-way NB/Third Ave One-way SB
Left turns from Kendrick St to Fourth Ave)

B	A	A
---	---	---

Kendrick St @ Third Ave:

- o Install Signal
- o Permit outbound movement only
(Third Ave One-way SB/Fourth Ave One-way NB)
Signalized Intersection--Overall Summary

C	A	C
---	---	---

Kendrick St @ Hunting Road:

- o Phase revision can be considered (no corrective
action considered, as left-turn failure is
relatively insignificant)

E	A	D
---	---	---

Kendrick St @ Greendale Ave:

- o NO ACTION NECESSARY

Webster St @ Greendale Ave:

- o NO ACTION NECESSARY

Webster St @ Highland Ave:

- o Revise Phasing to Include Overlapping (Actuated)
Left Lag from Highland Ave WB to Webster St
Signalized Intersection--Overall Summary

A	A	C
---	---	---

*Not meaningful

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PERFORMANCE SUMMARY
ALTERNATIVE IMPROVEMENTS

CTPS

TABLE

8-1b

turning restrictions that can be accomplished at the intersection which would effectively resolve the existing capacity and safety problems.

8.2.2 Highland Avenue at Second Avenue

One potential means of providing sufficient capacity to meet current demand and introducing greater control over vehicle operations at this intersection is the conversion of the Highland Avenue westbound approach to a configuration of two through lanes with one exclusive left-turn bay. This would permit through traffic approaching Second Avenue from the east to queue into two lanes and left-turning traffic to queue in a separate lane. At present, through traffic usually queues into only the right-hand lane, in anticipation of left-turn queues forming during the green phase. As right-lane queues lengthen during the red phase, through traffic begins to join the left-lane queue. When blockage occurs mid-phase, left-to-right-lane maneuvering occurs as through traffic attempts to circumvent the left-turn queue. Installation of an additional through lane would minimize vehicle maneuvering and would reduce queue lengths on Highland Avenue.

8.2.3 Needham Street at Oak Street and Christina Street

In consideration of the probability that the Needham Street at Oak Street and Christina Street intersection would be the westerly terminus of a three-lane Needham Street, a series of actions were considered to improve the operational capacity and level of service of the intersection under that scenario.

To permit improved access to Needham Street from Oak Street and Christina Street, signalization was considered. Under present conditions, left turns from Oak Street and all traffic from Christina Street is delayed for excessive periods throughout the day. Signalization would permit movement from the minor streets at regular intervals.

Present geometrics cause unnecessary maneuvering to occur within the intersection. Traffic moving between Oak and Christina is required to turn left and right on Needham Street in order to cross. Alignment of the two approaches would minimize maneuvering and permit safer and more efficient signal operations.

Additionally, observation of current traffic operations has shown that left-turn queues form on the eastbound Needham Street approach which often block through traffic and force passing traffic off the paved surface. Installation of a left-turn bay opposite the terminus of the CTWLTML would permit safer operations and minimize delay of through traffic.

During peak periods, approximately 50 percent of the Oak Street traffic proceeds westbound on Highland Avenue. To permit

this traffic to take advantage of right-turn-on-red provisions and limit interference with through and left-turn movements, an exclusive right-turn lane should be considered.

8.2.4 Needham Street at Winchester Street and Dedham Street

Recommendations to upgrade this location were initially prepared in 1973 as part of the Newton TOPICS plan. Analysis of the TOPICS-recommended geometric and signal improvements summarized in Table 8-1 indicates substantially better performance than under present conditions.

8.2.5 Winchester Street at Route 9 Eastbound Ramp

Under present conditions, eastbound Route 9 traffic exiting onto Winchester Street encounters significant delay in attempting to exit the ramp. The difficulty is caused by limited sight distances in either direction along Winchester Street which prevent motorists from adequately evaluating oncoming streams of traffic.

The stop line is presently set back from the mouth of the intersection to avoid conflict between left-turning vehicles exiting and approaching the ramp. Vehicles queued at the stop sign are unable to view traffic approaching from the south on Winchester Street due to the curvature of Winchester Street and the oblique angle of intersection with the ramp. To the north, the view is blocked by the bridge abutments.

Geometric improvements are necessary to solve the sight-distance problems. The approach to the intersection on the ramp could be upgraded by:

- o striping the ramp approach as exclusive left and right lanes;
- o placement of the stop line at the mouth of the intersection; and
- o establishment of an exclusive left-turn bay on the southbound Winchester Street approach.

The Newton TOPICS plan of 1973 recommended signalization in addition to geometric improvements for this location. Analysis of these recommendations under existing levels of demand indicates overall improvement in operations. Traffic operations at both Route 9 entrance/exit ramps are influenced, however, by operations at the Walnut Street/Centre Street and Needham Street/Winchester Street/Dedham Street intersections. Recent improvements at Walnut Street have alleviated the extensive queuing problems which previously had complicated operations at the ramp intersections, and further improvement in ramp operations can be expected from signalization and geometric upgrading

of the Needham Street/Winchester Street/Dedham Street intersection. Under present conditions, geometric improvements to the ramp intersection made in conjunction with full-scale improvements at the Needham Street/Winchester Street intersection should introduce sufficient gaps in through traffic streams to accommodate minor-street movements.

8.2.6 Centre Street at Route 9 Westbound On/Off Ramps

The Newton TOPICS report treated the eastbound and westbound Route 9 on/off ramp intersections as a single entity, recommending signals and geometric improvements at each. As suggested for the adjacent eastbound ramp intersection at Winchester Street, geometric improvements may be sufficient to address current problems at this location if implemented in conjunction with the upgrading of the Needham Street/Winchester Street intersection; the geometric improvements would be slightly more rigorous in this case, however. Full-scale signalization and geometric upgrading at Needham Street/Winchester Street would be expected to introduce gaps in northbound traffic flows and permit westbound off-ramp traffic to exit onto Centre Street more efficiently.

In addition to the geometric improvements recommended in the TOPICS study, consideration should be given to establishing a one-way (westbound) zone on the Route 9 ramp intersecting with Floral Street. This would eliminate the low-level demand of Floral-Street-generated traffic headed eastbound toward the Centre Street intersection. Establishment of a one-way zone would permit the segment to better function as a westbound Route 9 on-ramp and would eliminate the confusion caused by eastbound left turns at the intersection.

To maintain current levels of accessibility, a one-way westbound ramp would also require:

- o Construction of a separate driveway and barrier on the northside of the ramp to provide Centre Street access to the apartments fronting on the ramp. Telephone pole relocation or below-surface wire conduits would also be necessary.
- o Provisions for two-way traffic on Floral Street to permit resident access to Walnut Street.
- o Creation of a right-turn prohibition from the ramp to Floral Street to ensure that use of the street is limited to residential traffic.
- o Extension of the residential driveway immediately west of Floral Street which opens on the corner of the ramp and Floral Street to an opening which fronts on Floral Street to permit the resident Floral Street access.

9 RECOMMENDATIONS

The Highland Avenue/Needham Street Corridor Consensus Plan was developed in order to meet the perceived long-term needs of the Highland Avenue/Needham Street corridor. As such, the individual elements of the Consensus Plan were designed to accommodate both current and future levels of traffic demand. To date, these elements have only been tested as to their ability to provide for current levels of demand.

During the early data-collection phase of this study, problems involving vehicle movement and safety were identified at a number of locations within the Highland Avenue/Needham Street corridor. At each such location a variety of improvement alternatives, including the one contained in the Consensus Plan, were tested during the analysis phase in order to identify a "best" or "optimal" mix of improvements which could be made in order to correct, or at least improve upon, existing deficiencies.

The recommended solutions contained in this report are developed to be short term in nature. They require less time and are generally less expensive to implement than are major long-term actions. Many can be implemented within existing layout boundaries. They will not adversely affect the potential of other actions now under consideration for future implementation. Problem locations which can not be fully corrected through implementation of short-term actions are recommended for the greatest possible upgrade. These locations will then be considered for further improvements as part of future-year analysis.

The recommended short-term improvements for the Highland Avenue/Needham Street corridor are presented in Table 9-1 and Table 9-2. Each recommended action is listed by location, with the corresponding Consensus Plan action, if any, shown for comparison.

The recommendations in Table 9-1 are four in number. They have been separated out from the other recommendations as they are the furthest along toward implementation. They include the signalization of the intersections of Winchester and Dedham streets and Oak and Christina streets with Needham Street, the installation of a continuous two-way left-turn median lane on Needham Street between these two intersections, and the upgrading of the Second Avenue intersection with Highland Avenue.

The signal installations at Oak/Christina and Winchester/Dedham are recommended to increase safety by separating in time

<u>Location/Element</u>	<u>Consensus Plan Action</u>	<u>Short-Term Action</u>
2nd Avenue Intersection	<ul style="list-style-type: none"> o 5-lane roadway with 2 E-bound, 2 W-bound, 1 Continuous 2-way Left-Turn lane 	<ul style="list-style-type: none"> o West approach: 2 lanes o East approach: 3 lanes with 2 through and 1 exclusive left-turn lane to 2nd Ave S-bound o South approach: 3 lanes with 2 left-turn lanes to Highland Ave W-bound & 1 lane to Highland Ave E-bound
Oak/Christina Intersection	<ul style="list-style-type: none"> o Signalize o West approach: 2 through lanes (1 shared with right turns); 1 exclusive left-turn lane (continuation of Continuous 2-way Left-Turn lane) o East approach: 2 through lanes (1 shared with right turns; 1 exclusive left-turn lane (continuation of Continuous 2-way Left-Turn lane) 	<ul style="list-style-type: none"> o Align Christina with Oak, maintaining existing Oak alignment o Signalize o West approach: 1 lane with shared right turn & through; 1 exclusive left-turn lane o East approach: 1 lane with shared right-turn & through movements; 1 exclusive left-turn lane (continuation of Continuous 2-way Left-Turn lane) o North approach: 1 exclusive right-turn lane; 1 lane with shared left-turn & through movements o South approach: 1 lane shared by all movements

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RECOMMENDED SHORT-TERM ACTIONS:
ACTIONS CURRENTLY UNDERWAY

CTPS

TABLE

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<u>Location/Element</u>	<u>Consensus Plan Action</u>	<u>Short-Term Action</u>
Needham Street (Oak/Christina to Winchester)	o 5-lane roadway with 2 E-bound, 2 W-bound, 1 Continuous 2-way Left-Turn lane	o 3-lane roadway using existing paved surface with 1 E-bound, 1 W-bound, 1 Continuous 2-way Left-Turn lane
Dedham/Winches- ter Intersection	o Signalize & make geometric improve- ments	o Signalize & make geometric improve- ments

Highland Avenue/ Needham Street Traffic Analysis	RECOMMENDED SHORT-TERM ACTIONS: ACTIONS CURRENTLY UNDERWAY	CTPS
Technical Report 56a August 1986		TABLE 9-1b

<u>Location/Element</u>	<u>Consensus Plan Action</u>	<u>Short-Term Action</u>
1st Avenue	<ul style="list-style-type: none"> o Open median o Install traffic signal o Allow all movements inbound & outbound 	<ul style="list-style-type: none"> o Allow only inbound (EB-to-SB) right turn o Median remains closed o No traffic signal installed o 1-way SB traffic only (Highland Ave to HoJo driveway)
Jug-handle/Serv-ice Road (Jug-handle Effect at 2nd Ave)	Not an element	<ul style="list-style-type: none"> o Construct 1-way (W to E) roadway btwn 1st & 2nd aves to serve: <ul style="list-style-type: none"> (1) traffic both EB & WB originating in the NW corner of NEIC & exiting Center; & (2) left turns from Highland EB to Wexford NB, Charles NB, & land uses on north side of Highland btwn 2nd Ave & Rte 128 interchange area
Highland Avenue (2nd Ave to Rte 128)	<ul style="list-style-type: none"> o 5-lane roadway with 2 E-bound, 2 W-bound, 1 Continuous 2-way Left-Turn lane 	<ul style="list-style-type: none"> o 5-lane roadway with 2 E-bound, 2 W-bound, 1 Continuous 1-way (W-bound) Left-Turn lane for accessing land uses on south side of Highland btwn 2nd Ave & median o Median remains informally used as "safety island" for W-bound south-side left-turners

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RECOMMENDED SHORT-TERM ACTIONS:
ACTIONS UNDER CONSIDERATION
Package 1 (p.1)

CTPS

TABLE

9-2a

<u>Location/Element</u>	<u>Consensus Plan Action</u>	<u>Short-Term Action</u>
Highland Avenue Bridge	o 2 E-bound, 2 W-bound lanes	o 1 E-bound, 1 W-bound lane
Charles Street Intersection	None	<ul style="list-style-type: none"> o Split approach into 2 lanes with 1 exclusive right for W-bound traffic & 1 exclusive left for E-bound traffic o Operate under stop-sign control o Left-turn prohibition from Highland E-bound to Charles o No short-term solution for left-turns leaving Charles (i.e., traffic moving E-bound on Highland toward Newton)
Wexford Street Intersection	None	<ul style="list-style-type: none"> o Left-turn prohibition from Highland E-bound to Wexford o No short-term solution for left turns leaving land uses on north side of Highland served by Wexford (and Charles) and traveling E-bound on Highland Ave
Median U-Turns @ Wexford to travel W-bound toward Rte 128	o Median removed at 1st Ave, thus removing U-turn necessity but springing loose left turns	o Prohibition of left turns from Highland E-bound, with enforcement (Provision of facility for W-bound movement via jug-handle)

Highland Avenue/ Needham Street Traffic Analysis	RECOMMENDED SHORT-TERM ACTIONS: ACTIONS UNDER CONSIDERATION Package 1 (p.2)	CTPS
Technical Report 56a August 1986		TABLE 9-2b

<u>Location/Element</u>	<u>Consensus Plan Action</u>	<u>Short-Term Action</u>
3rd Avenue Intersection	Not included in geographic area of Consensus Plan	<ul style="list-style-type: none"> o 1-way operation of 3rd Ave S-bound* (outbound from NEIC) o Traffic-light-controlled S-bound 3rd Ave approach split into 1 exclusive right-turn lane & 1 exclusive left-turn lane o E-bound & W-bound approaches on Kendrick split to 2 through lanes each
4th Avenue Intersection	Not included in geographic area of Consensus Plan	<ul style="list-style-type: none"> o 1-way operation of 4th Avenue N-bound* (inbound to NEIC) o 4th Ave 2 lanes N-bound from intersection o Eastern approach on Kendrick split into 1 exclusive right-turn lane & 1 through lane o Western approach on Kendrick split into 1 exclusive left-turn lane & 1 through lane
"B" Street Extension	Not included in geographic area of Consensus Plan	<ul style="list-style-type: none"> o Connection of 3rd Ave & 4th Ave via extension of B St as 2-way roadway to ease circulation of traffic with separation of inbound & outbound "gateways" on southern side of NEIC

*Operation of 3rd and 4th avenues as one-way would be for only the first 500 feet north of Kendrick Street, i.e., as "gateway" points. Both 3rd and 4th would operate as two-way streets within the NEIC for internal NEIC-circulation purposes.

Highland Avenue/ Needham Street Traffic Analysis	RECOMMENDED SHORT-TERM ACTIONS: ACTIONS UNDER CONSIDERATION Package 2	CTPS
Technical Report 56a August 1986		TABLE 9-2c

<u>Location/Element</u>	<u>Consensus Plan Action</u>	<u>Short-Term Action</u>
Winchester Street/Route 9 EB Ramp Inter- section	o Signalize	o Flashing beacon with geometric improvements
Center Street/ Route 9 WB Ramp Intersection	o Signalize	o One-way operation with flashing beacon & geometric improve- ments
Floral Street	Not included in geo- graphic area of Con- sensus Plan	o Establish 2-way operation o Restrict access to ramp to right turn only o No physical barrier
Apartment Drive- ways	Not included in geo- graphic area of Con- sensus Plan	o Prevent access to Rte 9 ramp o Provide access to Center St

Highland Avenue/ Needham Street Traffic Analysis	RECOMMENDED SHORT-TERM ACTIONS: ACTIONS UNDER CONSIDERATION Package 3	CTPS
		TABLE 9-2d
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the major-street and minor-street traffic movements while providing a specific opportunity for the minor-street movements to occur. The establishment of the continuous two-way left-turn median lane along Needham Street is intended to formalize an already existing informal operations pattern in such a way as to better accommodate the numerous left turns that occur along this section of roadway while also improving the flow of through traffic. The lane-use modifications recommended for the Highland Avenue/Second Avenue intersection also fall into the category of formalizing already existing informal operating conditions.

The recommendations in Table 9-2, while still short-term in nature, are either more complex or less urgent. The first several, affecting the section of Highland Avenue between First Avenue and Second Avenue, are one integrated package and must be treated as such, not as individual, isolated elements. This package is recognized to be rather complex in nature when it comes to implementation, but it seems practical and its immediate benefits to existing traffic flow would be very substantial. The Third Avenue/Fourth Avenue/B Street Extension recommendations form a second package and need to be viewed together. The immediate need for the implementation of this package of improvements is not as great as for the previous one, but now is the time to deal with this section of Kendrick Street--before more serious problems develop. The final four recommendations, focused on the Route 9 ramp area, form yet another package.

Appendix A

REVIEW COMMENTS



NEWTON-NEEDHAM

CHAMBER OF COMMERCE, INC.

437 CHERRY STREET • NEWTON, MASSACHUSETTS • 02165

AREA CODE 617 • 244-5300

LEWIS B. SONGER, CCE
Executive Vice President

February 3, 1986

Mr. Lawrence H. Tittlemore
Central Transportation Planning Staff
State Transportation Building
10 Park Plaza, Suite 2150
Boston, Massachusetts 02116

Dear Larry:

I am writing on behalf of the technical advisory committee members (enumerated at the end of the letter) in response to our meeting with you and other state officials on Jan. 9th.

We wish to comment on the "Existing Conditions" draft report and presentation made to us at your offices by you and Bill Steffens.

With respect to the overall report we found that it describes the land uses and the present situation very well. It defines the problems accurately and reflects technical competence at a high level of analysis. Finally, it is very well written and easy to understand. Your presentation orally and the visual presentation and choice of graphics was very well done, too.

As an overall statement before we address the particulars, we should clearly state that the omission of the frontage road parallel to Route 128 needs to be corrected because without the frontage road there can be no long-term solutions to the problems for the corridor. There simply must be ways to enter the industrial park from Highland Avenue besides Second Avenue and the limited entry at First Avenue.

A) We are in agreement on several of your short-run recommendations:

1. That the installation of traffic lights at the Oak/Christina and Winchester/Dedham/Needham Streets intersections should proceed.
2. There is a need for coordinating the timing of the Oak/Christina light with the Second Avenue light.
3. That Needham Street be re-striped for three lanes to allow for left-turn movements.
4. That the median strip at First Avenue NOT be removed in the short run.
5. That the 5 lane configuration on Highland Avenue allow for a third lane westbound (continuous) to allow for southbound turns into Second Avenue.

(continued)



ACCREDITED
CHAMBER OF COMMERCE
OF THE UNITED STATES

B) We would suggest modifications on the following issues:

1. That the suggested improvements for Third and Fourth Avenue intersections with Kendrick Street proceed with the lane markings. The concept of one-way streets is not feasible because they cannot be connected by extending B Street without a major land taking. The possibility of lights at 4th and/or 3rd should be considered, also.
2. That the suggested left turn lane eastbound on Highland Avenue in the vicinity of Charles and Wexford Streets be limited to left turns only into Charles Street, because there so many more businesses north of Highland Avenue. This change would be predicated on continuing Charles Street as a two-way street and making Wexford Street a "Do Not Enter" street from Highland Avenue and requiring all traffic leaving Wexford Street be limited to right turn only toward Route 128.

This essentially captures the same concept as you suggest for Third and Fourth Avenue and would allow some stacking in the left turn lane eastbound without impeding other traffic eastbound. It could be done as a "pilot" program and if found to be unworkable, it could be abandoned.

3. We think further consideration needs to be given to the Floral Street/ramp connection recommendation (including considering making Floral Street two ways) to avoid trapping the apartment house residents.

C) We do not agree that:

1. In the short-run the jug handle solution is practical because of the land-takings that would be necessary.
2. We are also concerned about the suggested road to connect at the base of the hill with Second Avenue because it is too close to the intersection. Traffic would block Second Avenue southbound in trying to "get into line" on Second Avenue northbound. The very recent major and ongoing construction practically negates this possibility. Again the practicality involved in land-taking is not short-run. We do not agree that the bridge may not become, if it is not now, a bottleneck.

D) Also, we would like to suggest the following:

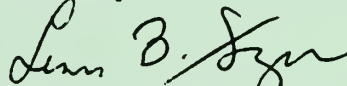
1. That the restriction right-turn-on red be removed at Second Avenue-Highland Avenue, thus creating a "release" in northbound Second Avenue backups.
2. That the entire program keep in mind that the impending opening of the Hillside Office building and the proposed opening of the Sheraton Hotel next Fall will have a substantial impact on area traffic and consideration be given to method of evaluating this impact.

We wish to emphasize the importance of accomplishing the re-stripping, lane designation, signage and turn restriction during the 1986 construction season and that every effort be made to assure that the final design, bidding and installation of the practical and orderly timetable be established for this key element in the plan.

We are concerned about the timing and sequence of the final report. Would we be correct in assuming that you will issue your final report by March 15? If so, it is important for us to arrange a meeting for a formal presentation to city and town officials as soon thereafter as possible.

Thank you for the opportunity to continue our work with you.

Sincerely,



Lewis B. Songer, CCE
Executive Vice President
(for the committee:)

LBS/ho

cc: Lewis Branzburg
Barry Canner
Calvin Cook
John Fox
Paul Giunta
Roy LaMotte
John Marr
Richard Robinson

April 7, 1986

Mr. Lewis Songer, CCE
Executive Vice President
Newton-Needham Chamber of Commerce, Inc.
437 Cherry Street
Newton, MA 02165

Dear Lew:

I would like to thank you for your letter on behalf of the Newton, Needham and Chamber of Commerce members of the Highland Avenue-Needham Street Technical Advisory Committee (TAC) containing your responses to the recommendations made in the "Preliminary Draft Existing Conditions Report." Your letter will be included as an appendix in the final version of that report along with this letter (and accompanying memorandum). During the coming month, the members of the TAC will also receive a detailed memorandum written by CTPS, at the request of the Massachusetts Department of Public Works. This memorandum explains specific problems that were identified and addressed concerning the portion of Highland Avenue between the Route 128 interchange and the Charles River.

We think it is important to reiterate why an existing conditions report was developed in the first place. During the course of our data collection and analysis, it became apparent that opportunities existed for making immediate improvements to traffic operations within the corridor. It was also apparent to us that the rapid commercial development now underway could foreclose long-term opportunities for improvement, if immediate steps were not taken to preserve the land necessary to accomplish these improvements. That is, the existing conditions report was designed to provide a means of:

- o Pointing out opportunities for making significant physical improvements of a relative short-term, inexpensive nature which are compatible with more long-term, capital intensive improvements that will also be necessary. Opportunities which fall into this category include signalization of unsignalized intersections, geometric upgrades, restriping of existing pavement and minor intersection widenings.
- o Also pointing out opportunities for protecting needed right-of-way now before the opportunity for acquisition of that right-of-way is lost. An example would be the reservation of land for a connection between Third and Fourth Avenues within the New England Industrial Center.


April 7, 1986

Your letter specifically notes the omission of the "Frontage Road" from the recommendations contained in this report. This is true only because of its long-term nature. This fact was not made clear in the draft of the report.

Due to the length of our responses, we have chosen to package our responses in the form of the attached memorandum. Each comment has been addressed in detail.

Again, we thank you for your comments. We look forward to working with you in advocating implementation of short-term opportunities during the 1986 construction season. We feel a united front must be presented in order to enhance the possibility of receiving a quick response to corridor needs from the MDPW.

Very truly yours,



Lawrence H. Tittlemore

LHT:od:53204

Attachment

cc: Barry Canner, Newton
Roy LaMotte, Newton
Calvin Cook, Needham
Jack Marr, Needham
Richard Robinson, Needham
John Fox, N/N Chamber of Commerce
Lewis Branzburg, N/N Chamber of Commerce
Michael Meyer, MDPW
John Gaynor, MDPW
Robert Patneaude, MDPW
Allan McKinnon, EOTC
Robert Sloane, EOTC
Edward Bates, MAPC

MEMORANDUM

TO: The Highland Avenue-Needham Street Corridor Technical Advisory Committee April 3, 1986

FROM: Lawrence H. Tittlemore
William T. Steffens

RE: Response to Newton-Needham Chamber of Commerce Letter of February 3, 1985

This memorandum serves as the CTPS response to the Newton, Needham and Chamber of Commerce members of the Highland Avenue-Needham Street Technical Advisory Committee (TAC) letter dated February 3, 1986. That letter contains comments concerning the recommendations within the "Preliminary Draft Existing Conditions Report for the Highland Avenue-Needham Street Corridor Traffic Study.

In section A of the letter, several comments were made that were stated to be in agreement with certain of the report recommendations.

Comment A.1: "That the installation of traffic lights at the Oak/Christina and Winchester/Dedham/Needham Streets intersections should proceed."

CTPS Response: While we did recommend that signals be installed at the Oak Street/Christina Street intersection, we do not recommend that these improvements proceed as currently planned by the Massachusetts Department of Public Works (MDPW). We believe that an integral part of this improvement requires that the Christina Street center line be brought into alignment with that of Oak Street and that the Oak Street approach be striped to accommodate an exclusive right-turn lane and a shared left-turn/through lane. The current MDPW plans do not contain either of these features. Without these features the signalization will introduce more delay than is necessary on Needham Street and unsafe vehicle maneuvering will continue.

Comment A.2: "There is a need for coordinating the timing of the Oak/Christina light with the Second Avenue light."

CTPS Response: Although we generally agree with the recommendation cited in A.2, we are not responsible for a recommendation proposing signal coordination between these intersections. The Manual on Uniform Traffic Control Devices (MUTCD) specifies that traffic control signals within 1/2 mile of one another should be

operated in coordination. Oak Street and Second Avenue do fall within 1/2 mile of one another. As also stated in the MUTCD, "...coordination need not be maintained across boundaries between signal systems which operate on different time cycles." This is an important caveat since adjustments to signal operations to accommodate coordination schemes necessitate the establishment of a "priority intersection" because phasings and timings are seldom identical between any two intersections. Furthermore, we reserve the right to withhold such a recommendation pending a review of signal operations at each location.

Comment A.3: "That Needham Street be re-stripped for three lanes to allow for left-turn movements."

CTPS Response: For clarity, the recommendation states that the third (center) lane be striped as a continuous two-way, left-turn lane.

Comment A.4: "That the median strip at First Avenue NOT be removed in the short run."

CTPS Response: We concur.

Comment A.5: "That the 5 lane configuration on Highland Avenue allow for a third lane westbound (continuous) to allow for southbound turns onto Second Avenue."

CTPS Response: A five-lane section on Highland Avenue between Second Avenue and the Highland Avenue Bridge is not recommended for implementation under current traffic conditions. Not specifically stated is the need for maintaining the present cross-section to provide safe transition to the Highland Avenue Bridge which remains one lane in each direction. Our recommendation regarding the three-legged Highland Avenue/Second Avenue intersection proposes, for Highland Avenue, the maintenance of the existing two-lane eastbound approach and the addition of an exclusive left-turn lane to the two through lanes on the westbound approach. This exclusive left-turn lane is required to separate left turns from through traffic. For the Second Avenue approach to this intersection, we recommend restriping of the existing pavement to provide for two exclusive left-turn lanes and one exclusive right-turn lane.

In section B of the letter, modifications to the report recommendations were proposed.

Comment B.1: "That the suggested improvements for Third and Fourth Avenue intersections with Kendrick Street proceed with the lane markings. The concept of one-way streets is not feasible because they cannot be connected by extending B Street without a

major land taking. The possibility of lights at 4th and/or 3rd should be considered, also."

CTPS Response: The recommended improvements for these intersections depend heavily on the establishment of a one-way pair system, with signalization at Third Avenue, and depend less on lane striping. We fully understand that land acquisition would be necessary to connect Third Avenue and Fourth Avenue. It appears to us that such a connection could be accomplished using land that is presently unbuilt upon. The lane striping by itself would provide little aside from formalizing the existing pattern of use.

Comment B.2: "That the suggested left turn lane eastbound on Highland Avenue in the vicinity (sic) of Charles and Wexford Streets be limited to left turns only into Charles Street, because there [are] so many more businesses north of Highland Avenue. This change would be predicated on continuing Charles Street as a two-way street and making Wexford Street a "Do Not Enter" street from Highland Avenue and requiring all traffic leaving Wexford Street [to] be limited to right turn only toward Route 128. This essentially captures the same concept as you suggest for Third and Fourth Avenue and would allow some stacking in the left turn lane eastbound without impeding other traffic eastbound. It could be done as a "pilot" program and if found to be unworkable, it could be abandoned."

CTPS Response: For the segment of Highland Avenue between Second Avenue and Route 128, the recommendation is for the establishment of a five-lane cross-section with a continuous left-turn lane for westbound, not eastbound, traffic. We do not agree that left turns should continue to be allowed from eastbound Highland Avenue into either Wexford Street or Charles Street. It is these very turns which severely disrupt traffic operations at the Second Avenue intersection today.

The suggested modification to the Wexford/ Charles Street operation, (i.e., forcing all left turns to and from Wexford Street onto Charles Street), is of limited technical value and could prove counter-productive, if implemented. The extreme proximity of Charles Street to the Highland Avenue/Second Avenue signalized intersection would make left turns from the commercial area north of Highland Avenue even more difficult. This would be due to the persistent blocking effect caused by stopped eastbound traffic on Highland Avenue during the Highland Avenue red phase. In addition, a major portion of the storage space (the distance between Charles Street and Wexford Street) currently used by westbound Highland Avenue traffic when left turns are being made to or from Wexford Street would be eliminated. The direct result of this loss of storage space would be lengthened traffic queues in two directions, with one queue stretching back toward the Highland Avenue Bridge and the other queue stretching into the New England Industrial Center. The suggested modification

could only be fully accomplished if the Charles Street approach to Highland Avenue was brought into alignment with the Second Avenue approach to Highland Avenue. Charles Street and Second Avenue operations could then be brought under the control of a single signal. This would involve major land-taking and building demolition.

We agree that this modification appears similar in concept to the recommendation made for improved operations at Third Avenue and Fourth Avenue. However, the physical conditions and traffic demands of the two locations are vastly different and require different improvement strategies. Furthermore, we would neither recommend nor expect the MDPW to experiment with a "pilot" project in this critical area.

Comment B.3: "We think further consideration needs to be given to the Floral Street/ramp connection recommendation (including considering making Floral Street two ways) to avoid trapping the apartment house residents."

CTPS Response: These considerations would be made in the design stages. There appears to be sufficient right-of-way available to provide the apartments with direct Centre Street access.

In section C of the letter, two areas of disagreement with the recommendations made in the report were noted.

Comment C.1: "In the short-run the jug handle solution is [not] practical because of the land-takings that would be necessary."

CTPS Response: It is true that this is not a project that could be accomplished in the short-term. It was included because of the immediate need to protect its potential right-of-way from the almost continuous development that is occurring along Highland Avenue.

Comment C.2: "We are also concerned about the suggested road to connect at the base of the hill with Second Avenue because it is too close to the intersection. Traffic would block Second Avenue southbound in trying to "get into line" on Second Avenue northbound. The very recent major and ongoing construction practically negates this possibility. Again the practicality involved in land-taking is not short-run..."

CTPS Response: We agree that land acquisition is required to successfully implement this action. This is the same right-of-way protection referred to in the C.1 response. The time required to acquire the necessary right-of-way is a matter for the Town of Needham to address. As to the potential for problems to occur at the intersection of the service road with Second Avenue, we do not agree that problems of any magnitude would occur as northbound traffic demand along Second Avenue peaks when

southbound demand is low. If necessary, the service road could be signal controlled at Second Avenue in coordination with the Highland Avenue/Second Avenue signal.

With respect to the effect of recent construction work in the immediate area of the proposed right-of-way, it is presently unclear if there is sufficient space remaining for construction of the road. Until it is confirmed that the necessary right-of-way no longer exists, this recommendation should not be dismissed out-of-hand. One necessary element for the successful improvement of traffic conditions on Highland Avenue, especially in the area of Second Avenue, Charles Street, Wexford Street, and the intervening block face, is the elimination of eastbound Highland Avenue left turns. The "jug-handle" aspect of the service road between First and Second avenues would permit the conversion of these left turns into right turns made from the westbound Highland Avenue traffic stream and eliminate the present disruptive effects caused by this traffic.

Comment C.2 (cont'd): "...We do not agree that the bridge may not become, if it is not now, a bottleneck."

CTPS Response: The examination of bridge capacity presented in the report offers a comparison of available capacity and peak hour demand. As indicated in the report, the bridge offers a higher level of service than does the Second Avenue/Highland Avenue intersection to its west and the Oak Street/Christina Street/Needham Street intersection to its east. The conclusion drawn from this finding is that unless and until one or the other intersection is upgraded to a capacity level above that of the bridge, the bridge will never act as a "bottleneck". If, at some future time, intersection improvements are completed at either intersection which raise the capacity above that of the bridge and travel also increases above the present bridge capacity, the bridge could act as a constraint to vehicle flow. No intersection capacity improvement of this magnitude is currently contemplated.

In section D of the letter, two additional recommendations are suggested.

Comment D.1: "That the restriction [on] right-turn-on red be removed at Second Avenue-Highland Avenue, thus creating a "release" in northbound Second Avenue backups."

CTPS Response: We agree that consideration should be given to the removal of the right-turn-on-red restriction on northbound traffic at the Second Avenue approach to Highland Avenue. We do feel, however, due to a low volume of right turns, that this action would have only a minor positive effect on traffic flow. The negative aspect of this action would be to intensify an already difficult situation for pedestrian movement. Keep in mind, it was either a safety consideration or a request from

Needham officials that led to the imposition of the turn restriction in the first place. We again reiterate our recommendation to restripe the Second Avenue approach to Highland Avenue with two exclusive left-turn lanes and one exclusive right-turn lane.

Comment D.2: "That the entire program keep in mind that the impending opening of the Hillside Office building and the proposed opening of the Sheraton Hotel next Fall will have a substantial impact on area traffic and consideration be given to [a] method of evaluating this impact."

CTPS Response: The traffic impact of these developments, together with all other foreseeable corridor growth, has been considered in the study of future conditions.

LHT:WTS:dap

Appendix B

STUDY-AREA LAND USE

Appendix B

Description of Content

In the spring of 1983, the Metropolitan Area Planning Council undertook a comprehensive investigation of land use in the Highland Avenue/Needham Street Corridor study area. Land use inventories were compiled for each community by parcel, through a review of assessor's maps and follow-up field visits. Forecasts of future land use developments were based on zoning by-laws, discussions with community leaders and on proposals currently planned for construction within the corridor study area.

Both communities assisted in the research and forecasting efforts with staff time and the provision of documentation. This appendix contains the results of these combined efforts. The information is presented in report form and is of sufficient detail and content to be considered a separate, stand-alone product of this study.

LAND-USE STUDY OF THE
HIGHLAND AVENUE/NEEDHAM STREET CORRIDOR
IN NEEDHAM AND NEWTON

Metropolitan Area Planning Council
and
Central Transportation Planning Staff

August 1986

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EXECUTIVE SUMMARY

A detailed examination of land use in the Highland Avenue/Needham Street corridor is important in light of the burgeoning growth and development pressures occurring there. The major findings of this examination are as follows:

- o Land use in the study area ranges from residential around the periphery to more intensive retail, office, and industrial along major roadways.
- o Vacant land does not exist for development purposes in general.
- o The area is undergoing redevelopment of underutilized parcels for uses which are more intensive and for which there is more market demand.
- o Needham's portion of the study area's land use can be characterized as follows:
 - Route 128 bisects Needham's portion of the study area and serves as an effective buffer between highly divergent land uses.
 - West of Route 128 and south of Highland Avenue, the land use is virtually all residential. North of Highland Avenue, there is some office, retail, and light industrial development dominated by Muzi Ford.
 - East of Route 128 the land in Needham is characterized by non-residential development almost exclusively. North of Highland Avenue, local, service-oriented facilities prevail. Larger, regional businesses can be found in the New England Industrial Center south of Highland Avenue.
- o Newton's portion of the study area's existing land use is as follows:
 - Strip development, with a mix of retailers, characterizes the Needham Street corridor between the Charles River and Winchester Street, along with the somewhat ill-defined Newton Industrial Center, which filters down side streets near the Needham town line.
 - Industrial buildings in the corridor are low-rise, older structures with setbacks and off-street parking which are limited or nonexistent.

- There is a large residential area separating the Needham Street corridor from the Wells Avenue at Route 128 Office Park to the south; single-family homes predominate nearer to the corridor and the Jewish Community Center and Charles River Country Club predominate nearer to the office park.
- The Wells Avenue at Route 128 Office Park is a spacious complex consisting of low-rise buildings in a campus-like environment with generous setbacks and off-street parking.
- o In Needham, manufacturing is the principal land use, with 2.5 million square feet of building space, followed by office, with 875,000 square feet, and retail, with 230,000.
- o In Newton, manufacturing is also the principal land use, with 1.5 million square feet of building space, followed by office, with 1 million square feet, and retail, with 300,000.
- o New or probable developments in Needham as of 1984 are expected to total some 660,000 square feet of non-residential space.
- o New or probable developments in Newton as of 1984 are expected to total some 350,000 square feet of non-residential space and about 90 residential units.
- o Local land-use policies in Needham favor the residential character of the town, reject the encouragement of more industrial area, and encourage more intensive redevelopment of already developed areas contingent upon demonstration of acceptable impacts.
- o A recent study done by Lozano, White & Associates for the Needham Street corridor in Newton foresees a change from warehouse space to office and retail space via the redevelopment of a few large parcels and some smaller properties. Existing capacities of the sewer system and roadways are not adequate to handle major redevelopment in the corridor, and will be a major factor in controlling development in the next ten years.
- o A 1995 future-development scenario for Needham yields a net loss of about twelve residential units for a total of 558 units, and a net gain of approximately 1,070,000 square feet of non-residential development for a total of 4,625,000 square feet.
- o A 1995 future-development scenario for Newton yields a net gain of about 110 residential units for a total of 641 units, and a net gain of approximately 685,000 square feet of non-residential development for a total of 3,672,871 square feet.

If growth is to be successfully accommodated in the Needham/Newton study area, and unbridled development checked, more stringent local controls on land use and growth will be necessary.

1 EXISTING CONDITIONS

1.1 OVERVIEW

A land-use inventory has been compiled using data from Needham and Newton assessors' records of the square footage of buildings for each of three generalized land-use types: manufacturing, office, and retail. In addition, residential land-use data have been collected as they relate to the number of housing units--and the units per acre for high concentrations of homes--in the study area. These data were used for trip-generation purposes.

Figure 1-1 depicts the general land uses in the study area as of the base year of 1984. Land use in the study area ranges from residential around the periphery to more intensive uses such as retail, office, and industrial along major transportation thoroughfares. Vacant land, for the most part, is not available for development purposes. Instead, new development in the area is occurring through the redevelopment of presently underutilized parcels for more intensive uses for which there is currently more of a demand.

The mix of land uses is not compatible in some areas, with the intensity of uses varying markedly, thereby exacerbating the problems along the Highland Avenue/Needham Street corridor. Figure 1-2 presents generalized zoning districts for the study area.

1.1.1 Needham

Needham's portion of the study area is bisected by Route 128, which serves as an effective buffer between highly divergent land-use types. West of the Route 128 right-of-way, the land use south of Highland Avenue is virtually all residential to Webster Street and Tower Avenue on the west. As this area is zoned for single residences and is an established residential district, no commercial or industrial intrusions are to be anticipated; there is some office, retail, and light industrial development to the north of Highland Avenue, which becomes more intensive as one approaches Route 128 from the west. The parcel of land presently occupied by Muzi Ford, a large car dealership, anchors this area.

East of the Route 128 right-of-way, the existing land use is almost exclusively non-residential in character. Here, Highland Avenue is bordered by more local, service-oriented facilities,

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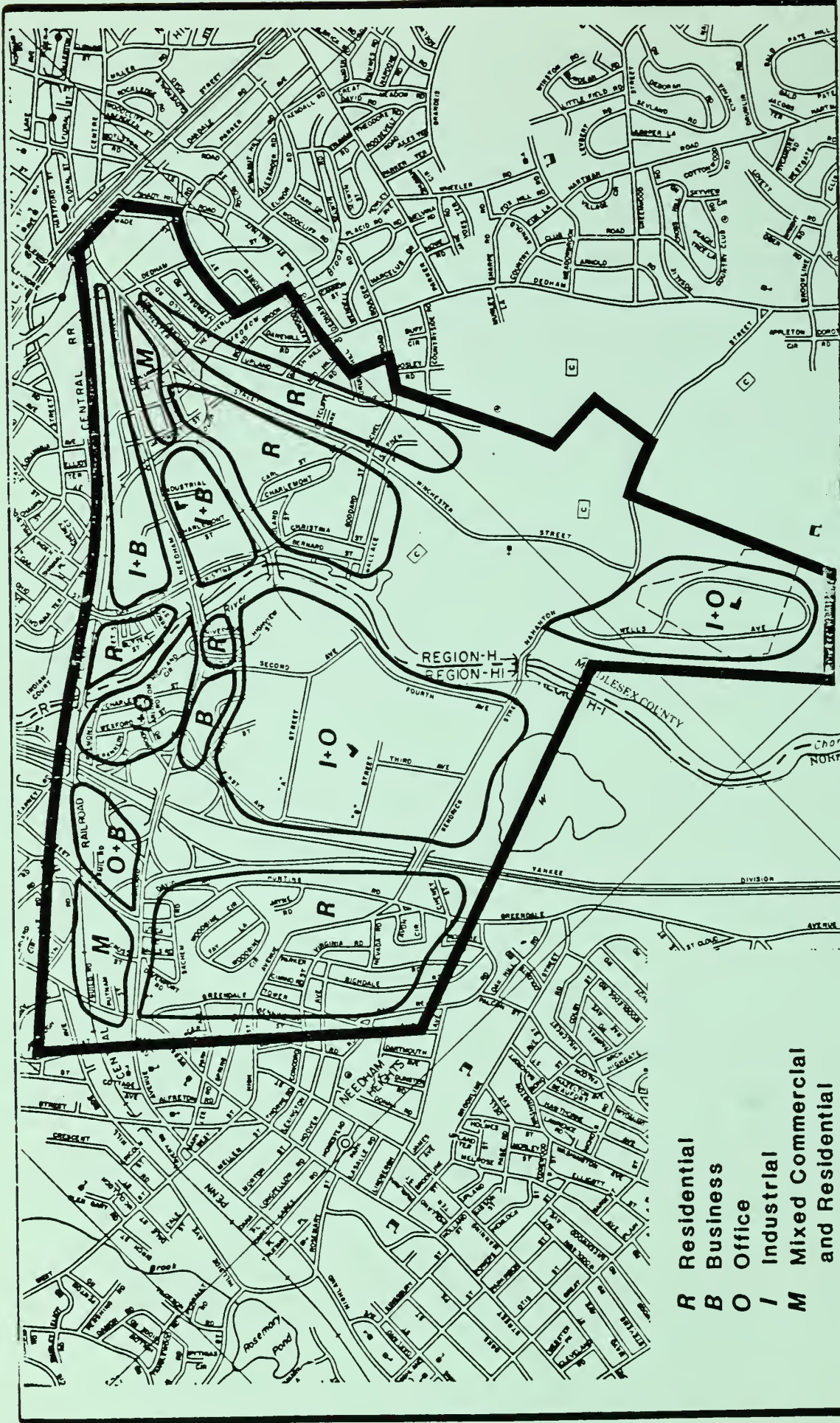
FIGURE

1-1

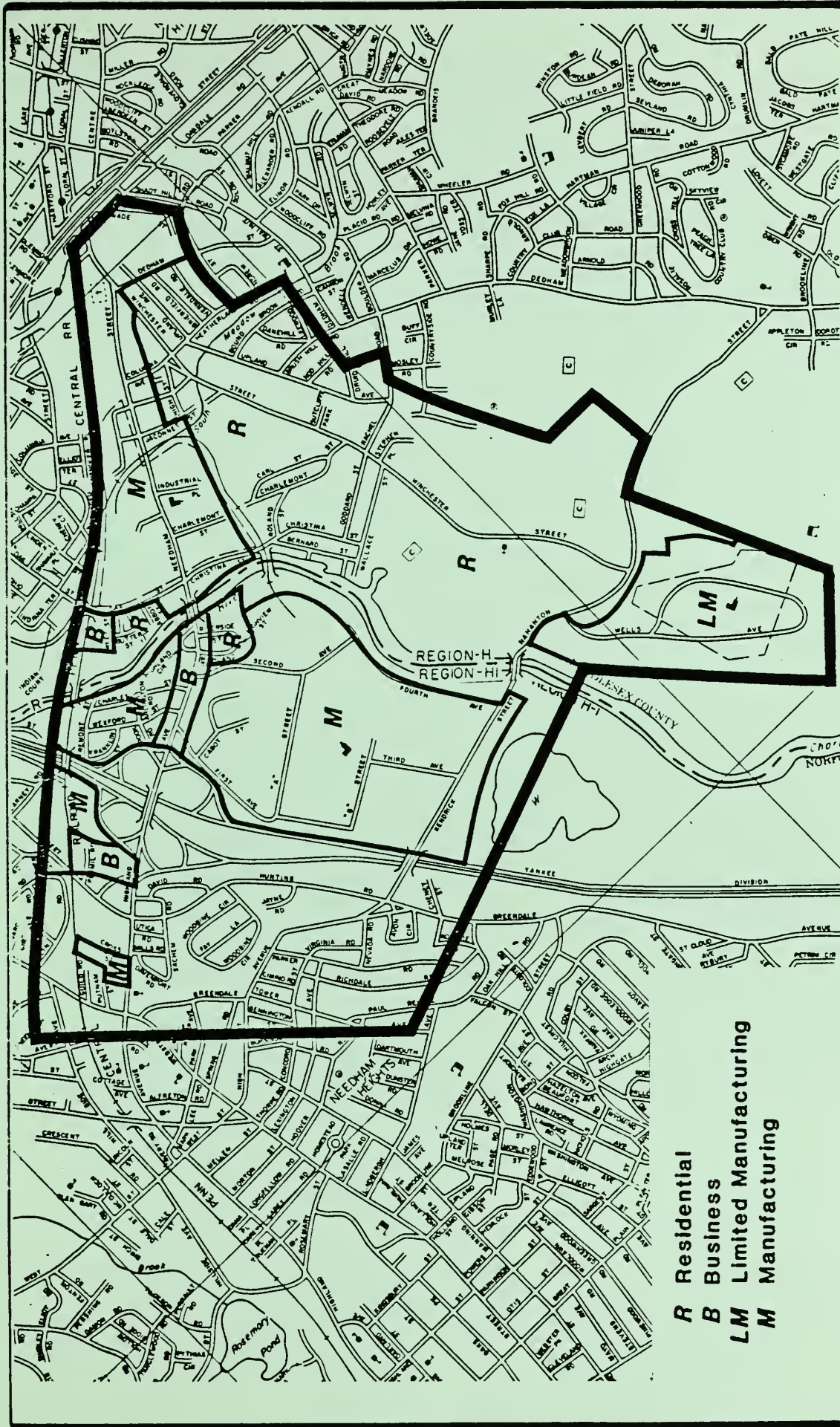
GENERAL LAND-USE MAP

Highland Avenue/
Needham Street
Traffic Analysis

August, 1986



R Residential
B Business
O Office
I Industrial
M Mixed Commercial
and Residential



R Residential
 B Business
 LM Limited Manufacturing
 M Manufacturing

Highland Avenue/
 Needham Street
 Traffic Analysis

August, 1986

CTPS

FIGURE

1-2

GENERAL ZONING-DISTRICT MAP

with the larger, regional businesses occupying the "off-Highland" sites, culminating in the New England Industrial Center, located on the southern side of the street. As the industrial park is zoned for manufacturing, which is an inclusive zoning district in Needham, some business uses as well as most office and manufacturing uses are allowed by right or special permit. The strip zoned for business that borders Highland Avenue allows single-family residences as of right and manufacturing uses by special permit.

Land use becomes less intensive near the Charles River/Newton line, with smaller businesses and residences abutting Highland Avenue. The residential district at Highland Terrace/Riverside Street, located to the southern side of Highland Avenue, stands as a bastion against development and is reflective of a time when Needham was not confronted with heavy demands for, and pressure from, development. Unlike those residential units across the street on the northern side of Highland Avenue, this area is likely to remain unchanged in the near term.

1.1.2 Newton

Across the Charles River, more intensive land uses again prevail, with a mix of commercial and light industrial uses bordering Needham Street. Strip development characterizes the corridor between the Charles River and Winchester Street to the east, with a myriad assortment of retailers and the sprawling, somewhat ill-defined Newton Industrial Center (NIC) spilling over each side of Needham Street and filtering down Tower Road on the northern side and Industrial Place and Charlemont Street on the southern side of Needham Street.

The NIC is actually a number of small industrial parks situated on these side streets. They are located on one-way or dead-end roads, which protects adjacent residential areas. The industrial buildings are, for the most part, low-rise, older structures with setbacks and off-street parking that are limited or absent. They are generally "orphans," associated with the Needham Street area's former role as an industrial center.

The Needham Street corridor is undergoing a complex infill scenario accompanied by changes both in scale of development and in predominant use. Interspersed among the industrial uses in the NIC are newer retail and office complexes, including the 60,000-square-foot Marshall's Shopping Plaza. This scenario occurs as a result of zoning areas for lighter industrial or heavy commercial uses, for which the ordinance provisions are more flexible than for typical retail commercial zones.

The zoning in the Needham Street corridor (approximately 200 feet to either side of the street) is for manufacturing. This zoning classification in Newton is at present essentially an "open door" zone. Such zoning can act as a conduit for related activities to come in and cannibalize parcels which are ripe for

conversion to uses for which there is more market demand. The office intrusions along Needham Street that are already taking place have led to speculation as to what will become of some of the larger industrial parcels that border Needham Street in the near future.

There is a large residential area separating the Needham Street corridor from the Wells Avenue at Route 128 Office Park to the south. This includes a thickly settled area of single-family homes nearer to the corridor and more open land, containing the Jewish Community Campus and the Charles River Country Club, nearer to the office park. These latter parcels, because of their proximity to Wells Avenue, are prime sites for more intensive uses, assuming that demand remains strong in the future.

The Wells Avenue at Route 128 Office Park comprises mostly low-rise, expansive buildings in a campus-like environment with sufficient off-street parking. It is zoned "limited manufacturing," which allows certain commercial, office, and industrial uses by right. Although a range of uses is permitted, the large number of office buildings reflects the demand for office space in the area. With a ceiling cap on office development at 1,200,000 square feet, which has nearly been reached, Newton will experience additional pressure from outside to allow more office developments in this area.

1.2 ANALYSIS OF DATA

Data has been compiled on the current land uses in the study area in terms of housing units and square footage of office, retail, and manufacturing buildings. This information was gathered from the Needham and Newton assessors' offices and from field visits to each community, as well as in conversations with local planners and officials.

The square footage of existing non-residential buildings was classified, using assessors' records, by predominant land-use type for trip-generation purposes. When available, the specific type of business was identified.

Manufacturing is the principal land use in the Needham section, with 2.5 million square feet of space, followed by office with 875,000 square feet and retail with 230,000. The New England Industrial Center is clearly in evidence in these numbers.

In Newton, as in Needham, manufacturing is the principal land use, with 1.5 million square feet of space, followed by office with 1.2 million square feet and retail with 300,000. The Newton Industrial Center accounts for most of the manufacturing total, while the more recent growth in office development can be seen in the Wells Avenue at Route 128 Office Park, which accounts for two thirds of the office total. Retail uses are confined to the Needham Street corridor.

The largest number of residential units in the study area can be found west of Route 128 in Needham, an area characterized by single-family homes on larger lots, with vacant land virtually nonexistent. The Winchester Street area of Newton has a large concentration of homes on smaller lots, with considerable open space. Finally, the cluster of homes in Needham east of Second Avenue merits inclusion, primarily because of its location in the corridor and the traffic impacts it generates and receives.

1.3 SUBAREA CHARACTERISTICS

The study area has been divided into a number of subareas, for ease in interpretation as well as a finer breakdown of data on residential, office, retail, and manufacturing uses. There are five subareas in Needham and three in Newton, as shown in Figure 1-3; land-use statistics for each are presented in Table 1-1.

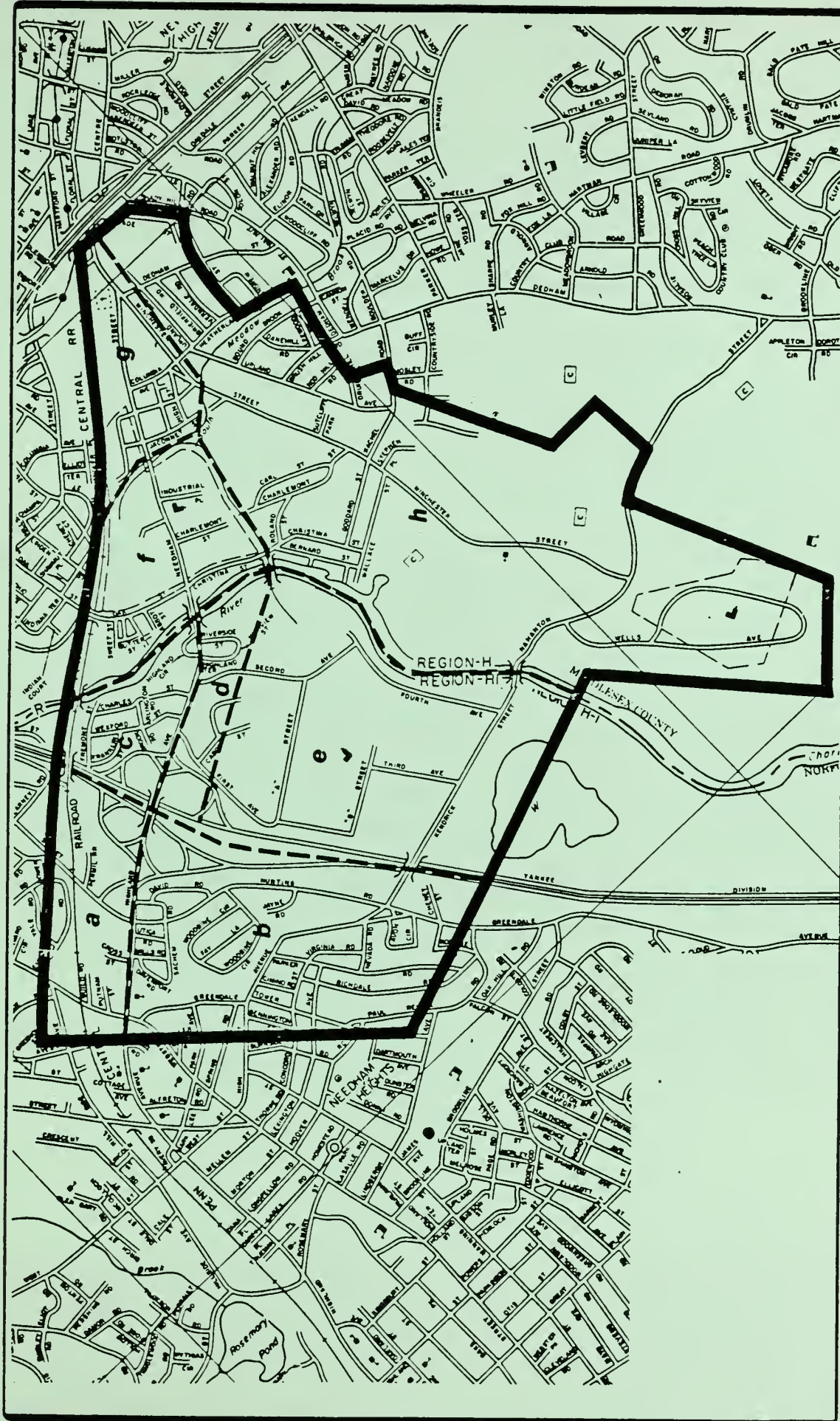
1.3.1 Needham

Needham has been divided into subarea A (north of Highland Avenue from Webster Street to Route 128), subarea B (south of Highland Avenue from the study area's western boundary to Route 128), subarea C (north of Highland Avenue from Route 128 to the Newton line), subarea D (south of Highland Avenue from Route 128 to the Newton line by including only the swath of land abutting Highland Avenue and the residential area of Highland Terrace), and subarea E (south of Subarea D from Route 128 to the Newton line, including almost all of the New England Industrial Center).

Subarea A is characterized by a mix of land uses which generally follow the pattern of industrial nearest the railroad and highway, office and retail along Highland Avenue, and residential along the side streets. Muzi Ford dominates the area, because of its visibility from the highway, and acts as a cornerstone for the industrial uses to its north and the newer retail and office uses trickling down Highland Avenue. It acts, in effect, as the gateway to Needham and, with the New England Industrial Center, is what most people who travel Route 128 have come to visually associate with Needham.

Subarea B, with the exception of a single office building, is an established residential area. Single-family homes predominate, reinforcing Needham's image as a residential suburb.

Subarea C is primarily a non-residential area characterized by industrial uses closer to the railroad and Route 128, with office and retail uses along or just behind Highland Avenue; a few residences remain, huddled around Highland Circle. Because of the lack of through streets and the historical industrial development of the area, the existing uses are crowded together, with no thought to setbacks or landscaping. This, as well as the



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FIGURE

1-3

LAND-USE SUBAREA BOUNDARY MAP

Highland Avenue/
Needham Street
Traffic Analysis

August, 1986

Subarea A (Assessor's maps 70, 76, 77, 78, 79, 94)

Residential	58 units on 25.7 acres = 2.3 units/acre
Office	148,832 square feet
Retail	40,142 square feet
Manufacturing	28,560 square feet

Subarea B (Assessor's maps 57, 58, 59, 60, 64, 65, 66, 67, 68, 71, 72)

Residential	457 units on 157.9 acres = 2.9 units/acre
Office	5,992 square feet
Retail	-
Manufacturing	-

Subarea C (Assessor's maps 74, 75)

Residential	12 units on 2.3 acres = 5.2 units/acre
Office	168,521 square feet
Retail	97,645 square feet
Manufacturing	221,809 square feet

Subarea D (Assessor's maps 73, part of 300)

Residential	43 units on 8 acres = 5.4 units/acre
Office	26,010 square feet
Retail	49,086 square feet
Manufacturing	52,880 square feet

Subarea E (Assessor's map 300)

Residential	-
Office	525,321 square feet
Retail	42,103 square feet
Manufacturing	2,112,348 square feet

Highland Avenue/
Needham Street
Traffic Analysis

August, 1986

HOUSING UNITS AND
NON-RESIDENTIAL BUILDING SPACE
NEEDHAM SUBAREAS

CTPS

TABLE

1-1a

Subarea F (Assessor's maps 51/28/5-8G, 51/49/6, 83/28/77-84,
83/30/9-12, 83/31/25&26)

Residential	77 units
Office	98,962 square feet
Retail	186,469 square feet
Manufacturing	985,221 square feet

Subarea G (Assessor's maps 51/28/11-30, 83/3/44-53, 83/11/14-23,
83/12/1-8, 83/13/4-13, 83/28/1+2)

Residential	50 units
Office	299,091 square feet
Retail	111,061 square feet
Manufacturing	191,747 square feet

Subarea H (Assessor's maps 83/36/4, 84/34/2A-2U, 84/341/1-8)

Residential	419 units on 32.5 acres = 12.9 units/acre
Office	839,913 square feet
Retail	5,753 square feet
Manufacturing	274,747 square feet

Highland Avenue/
Needham Street
Traffic Analysis

August, 1986

HOUSING UNITS AND
NON-RESIDENTIAL BUILDING SPACE
NEWTON SUBAREAS

CTPS

TABLE

1-1b

small size of the parcels, acts as a hindrance to major redevelopment of the subarea.

Subarea D is also characterized by a mix of land uses, with residential anchoring the Newton border, retail and office abutting Highland Avenue, and manufacturing leading into the New England Industrial Center. This is where Second Avenue, the principal ingress/egress of the industrial park, intersects with Highland Avenue.

Subarea E is the New England Industrial Center (NEIC), predominantly industry-oriented but with a sizable office segment as well. It is this development which has made industry of growing significance to the economy of Needham. The NEIC is contained by the Charles River Reservation to the south, the Charles River to the east, and Route 128 to the west. To the north, however, Highland Avenue interrupts the natural northward extension of the industrial area to the railroad.

The automobile orientation of Highland Avenue has lent itself to the development of the corridor first as a commercial strip, and now as a mixed commercial and office strip. Subarea C's smaller service establishments north of Highland Avenue are presently experiencing encroachment from office buildings, as evidenced by the Babcock-AAA building. These factors have contributed to the present state of flux, which will no doubt continue until market pressures ease. The NEIC is characterized by a large number of manufacturing and distribution centers. Minimal building setbacks and limited off-street parking, as well as the street layout within the Center, combine to form a visual morass.

1.3.2 Newton

Newton has been divided into subarea F (both sides of Needham Street between the railroad rights-of-way to the north and south, from the Charles River to the railroad right-of-way west of Jaconnet Street), subarea G (both sides of Needham Street between the railroad right-of-way to the north and Winchester Street to the south, from the railroad right-of-way west of Jaconnet Street to Curtis Street on the east), and subarea H (the Winchester Street area south of the railroad right-of-way, including the Wells Avenue at Route 128 Office Park, west to the Charles River).

Subarea F contains the Newton Industrial Center and the newer Marshall's Shopping Plaza. Although this area is heavily manufacturing-oriented, the last few years have seen more office and retail growth, resulting in a link between the commercial strip in Needham and that in subarea G to the east. One-way and dead-end streets off Needham Street give a feeling of congestion and crowding to the Newton Industrial Center. The residential area off of Oak Street is hemmed in by nonresidential uses, the railroad, and the Charles River.

Subarea G contains a more balanced mix of office, retail, and manufacturing uses than subarea F. Without a confining railroad right-of-way to the south, this area has been able to diversify, and is characterized by a number of office uses, followed by manufacturing and retail, respectively. An ill-defined, congested residential area serves as a buffer for the residences south of Winchester Street, in effect taking the place of the railroad right-of-way buffer to the west.

Subarea H is effectively two districts: a large residential area, and the Wells Avenue at Route 128 Office Park. The residential area has more houses per acre than the one in Needham, but is also characterized by areas of open space. The office park, against the Charles River/Needham border, is a well-planned, sprawling office and warehouse area providing generous setbacks and off-street parking. It presents a pleasant work environment and an attractive location, and has attained nearly 100-percent occupancy.

2 PROJECTED LAND-USE DEVELOPMENTS

By the year 1995, the land-use characteristics of the Highland Avenue/Needham Street corridor will have changed. The extent and nature of the change which takes place will depend on several factors:

- o community land-use and zoning policies;
- o market forces;
- o individual land-owner decisions; and
- o improvements in transportation and infrastructure.

Each of these factors has been taken into consideration in forming a basis for projecting 1995 study-area land use.

2.1 COMMUNITY LAND-USE POLICY

Recent study efforts undertaken by both Needham and Newton have identified general and specific land-use policies which relate to the corridor study area. The land-use policy of the town of Needham was most recently discussed in a document entitled, Planning Studies, 1983, published April 6, 1983 by the Needham Planning Board.

The future land-use policy expressed by the Town in this report, as it affects the study area, can be summarized and restated as follows.

- o Land use in Needham is predominantly residential, both in fact and by policy choice.
- o Major change to the overall land-use pattern is neither likely nor desired.
- o Any major expansion of non-residential uses will require more intensive redevelopment of already-developed areas.
- o There is an existing policy that further intensification in industrial areas should be facilitated only upon demonstration of acceptable impacts, especially on traffic. The Town chooses not to encourage increases in the extent of industrial areas, so more intensive use is the only possible alternative.

- o The re-use of properties along Gould Street will require careful planning to balance economic development and residential uses.

The City of Newton studied the Needham Street corridor land-use issues in detail more recently, with the assistance of Lozano, White & Associates. The findings have been documented in a report entitled, The Needham Street Corridor: Proposals for the Future (November, 1984). The major findings and policy recommendations made in the report are as follows.

- o The extensive warehouse space in the corridor is likely to be changed to higher-value uses, such as office and retail space.
- o The corridor is attractive for office-space development, which is now taking place on Highland Avenue in Needham.
- o The suitability of the corridor for additional retail use is evident from the success of the existing stores (e.g., Marshall's Plaza).
- o Traffic conditions are poor in the corridor, with no firm plans for improvement. Retail stores, which thrive on traffic, may be more attractive to developers than office buildings.
- o Only a few large parcels appear prime for development in the near future (e.g., St. Regis and New England Concrete Pipe). Other, larger sites have been locked up by long-term leases, acquisitions and improvements. Assembly of smaller parcels is costly and takes time.
- o Development of smaller properties is likely, both for offices and retail.

According to the Lozano, White & Associates study, development for the next eight to ten years can be anticipated as follows:

- o St. Regis property - access to Route 128 and ample size (17 acres) make the site a natural for large-scale office development. At least 680,000 square feet could be developed here under existing zoning, with at-grade parking.
- o New England Concrete Pipe property - ample size (8.5 acres) but limited frontage suggests such uses as retail (shopping center) or an owner-developed office building. Some 370,000 square feet of office space could be developed here with at-grade parking, with as much as 700,000 square feet possible with a parking structure. Alternatively, a 150,000-square-foot shopping center could be built.

- o Smaller parcels - projects totalling 285,000 square feet are now in the planned or rumored stages.
- o If the St. Regis and the New England Concrete Pipe properties were redeveloped, and other planned projects went ahead, a total of at least 1.3 million square feet of office space could be constructed in the corridor.

2.2 MARKET FORCES AND INFRASTRUCTURE CONCERNS

Since 1983, the Town of Needham has received several proposals from developers which, when totalled, would add some one million square feet of office and commercial space to the study area. In the city of Newton, small-parcel projects in the Needham Street corridor either rumored or in the planning stages total some 285,000 additional square feet of active use. In addition to this, if the St. Regis and the New England Concrete Pipe properties were redeveloped, at least one million square feet of new office space could be constructed in the corridor.

In Newton's study of Needham Street corridor land use, the point is made that existing sewer-system capacity is not adequate for this amount of additional development and that this will be a major factor in the amount of development which can occur in the corridor over the next ten years. It is unclear whether similar problems exist in Needham; however, sufficient sewer capacity for this level of development can be provided through reconstruction of the Charles River interceptor. No schedule has as yet been set for this replacement.

2.3 1995 LAND USE PROJECTIONS

On the basis of existing land use, proposed and expected development proposals, local policies, and an assumed continuation of market pressure for further development through 1995, land-use forecasts were prepared for each of the eight study-area subdivisions. These forecasts are presented in Table 2-1 under the general land-use headings residential, office, retail, and manufacturing. Uses which do not fall precisely into one of these categories are separately categorized. Dwelling-unit additions and deletions are used to describe changes in residential use, while square-footage adjustments define the anticipated developments in office, retail and manufacturing categories.

The anticipated changes forecast for subarea A in Needham include three office-building proposals submitted to the Town as of 1984. The racquetball building is expected to be converted into office space and Muzi Ford is expected to be redeveloped into offices by 1995. Red Ball manufacturing is also expected to be converted into office space. The addition of 5,000 new square feet of retail space is anticipated.

No changes are anticipated in Needham's largely residential and nearly fully developed subarea B.

<u>Subarea A</u>	<u>Existing 1983</u>	<u>Projected 1995</u>
Residential	58 units	58 units
Office	148,832 sq. ft.	604,832 sq. ft.
Retail	40,142 sq. ft.	7,422 sq. ft.
Manufacturing	28,560 sq. ft.	9,240 sq. ft.
Racquetball	27,167 sq. ft.	
<u>Subarea B</u>		
Residential	457 units	457 units
Office	5,922 sq. ft.	5,922 sq. ft.
Retail	0	0
Manufacturing	0	0
<u>Subarea C</u>		
Residential	12 units	0 units
Office	168,521 sq. ft.	347,371 sq. ft.
Retail	97,645 sq. ft.	100,145 sq. ft.
Manufacturing	221,809 sq. ft.	171,809 sq. ft.
<u>Subarea D</u>		
Residential	43 units	43 units
Office	26,010 sq. ft.	64,260 sq. ft.
Retail	49,086 sq. ft.	53,086 sq. ft.
Manufacturing	52,880 sq. ft.	52,880 sq. ft.
<u>Subarea E</u>		
Residential	0 units	0 units
Office	525,321 sq. ft.	716,721 sq. ft.
Retail	228,976 sq. ft.	202,756 sq. ft.
Manufacturing	2,112,348 sq. ft.	2,366,742 sq. ft.
Hotel	43,100 sq. ft.	86,200 sq. ft.
<u>Needham Summary</u>		
Residential	570 units	558 units
Office	874,606 sq. ft.	1,739,106 sq. ft.
Retail	415,849 sq. ft.	363,409 sq. ft.
Manufacturing	2,415,597 sq. ft.	2,600,671 sq. ft.
Racquetball	27,167 sq. ft.	0
Hotel	43,100 sq. ft.	86,200 sq. ft.

Highland Avenue/
Needham Street
Traffic Analysis

August, 1986

LAND USE BY SUBAREA,
EXISTING AND PROJECTED

CTPS

TABLE
2-1a

<u>Subarea F</u>	<u>Existing 1983</u>	<u>Projected 1995</u>
Residential	77 units	77 units
Office	98,962 sq. ft.	631,462 sq. ft.
Retail	186,469 sq. ft.	203,969 sq. ft.
Manufacturing	985,221 sq. ft.	555,221 sq. ft.
<u>Subarea G</u>		
Residential	50 units	50 units
Office	299,091 sq. ft.	520,591 sq. ft.
Retail	111,061 sq. ft.	202,756 sq. ft.
Manufacturing	191,747 sq. ft.	264,647 sq. ft.
<u>Subarea H</u>		
Residential	402 units	514 units
Office	644,725	769,725 sq. ft.
Retail	5,753	5,753 sq. ft.
Manufacturing	319,547	519,547 sq. ft.
Jewish Community Campus:		
Housing	99 units	99 units
Other	123,000 sq. ft.	145,000 sq. ft.
<u>Newton Summary</u>		
Residential	529 units	641 units
Office	1,042,778 sq. ft.	1,921,778 sq. ft.
Retail	303,283 sq. ft.	412,478 sq. ft.
Manufacturing	1,496,515 sq. ft.	1,339,415 sq. ft.
Jewish Community Campus:		
Housing	99 units	99 units
Other	123,000 sq. ft.	145,000 sq. ft.
<u>Study Area Totals</u>		
Residential	1,099 units	1,199 units
Office	1,917,384 sq. ft.	3,660,884 sq. ft.
Retail	719,132 sq. ft.	775,887 sq. ft.
Manufacturing	3,912,112 sq. ft.	3,940,086 sq. ft.
Racquetball	27,167 sq. ft.	0
Hotel	43,100 sq. ft.	86,200 sq. ft.
Jewish Community Campus:		
Housing	99 units	99 units
Other	123,000 sq. ft.	145,000 sq. ft.

Highland Avenue/ Needham Street Traffic Analysis	LAND USE BY SUBAREA, EXISTING AND PROJECTED	CTPS
August, 1986		TABLE 2-1b

Subarea C is expected to undergo substantial redevelopment by 1995. The twelve residential units are expected to be redeveloped as offices and supporting retail establishments. As of 1984, the Town had received four office-building proposals for the area. Several small manufacturing and retail sites are also expected to be reassembled as larger parcels suitable for office buildings.

In subarea D, no change is anticipated in the residential section or in the amount of manufacturing uses through the 1995 horizon year. Retail use will be increased by the expansion of Berijik Olds currently underway. Office development is also expected to increase; two office-building proposals had been received by the Town as of 1984.

In subarea E (the New England Industrial Center), while manufacturing developments are expected to continue in the foreseeable future, the mix of use will change as office buildings become more apparent and a 36,000-square-foot hotel is opened.

In Newton, in subarea F, present proposals under consideration by the City and projects already underway include both expansion and new construction of office buildings and plans for two new retail establishments. Conversion of the Saint Regis paper plant into approximately 400,000 square feet of office space is anticipated by 1995.

Subarea G is currently experiencing new demands for additional office space. By 1995 the New England Concrete Pipe facility is expected to be redeveloped into a mixed-use office-and-retail complex. Certain other small manufacturing sites are also expected to be converted into retail and possibly office developments. The residential section is expected to be unchanged.

In subarea H, proposals for additional residential development are presently under review by the City. The remaining vacant land in the Wells Avenue at Route 128 Office Park is also expected to be developed by 1995 and should include both manufacturing (R&D) and office buildings. At the Jewish Community Campus, an addition of as much as 25 percent is expected by 1995.

Overall, the pressure for continued development is expected to remain high within the study area through the 1995 horizon year. The greatest demand will be for new office space, and the recent trend toward the conversion of manufacturing and residential uses into office space will continue. In total, more than 2,000,000 square feet of new commercial and industrial development can be expected by 1995 in the study area.

Appendix C

INTERSECTION AND ROAD SEGMENT PHYSICAL
AND FUNCTIONAL INVENTORY

Appendix C

Description of Content

A comprehensive inventory of the physical and functional characteristics of the study area intersections and roadways was prepared and is presented in this appendix. Intersection characteristics are described for each of the study area intersections on Highland Avenue, Needham Street, Nahanton Street and Kendrick Street. The data for each is presented on a sheet entitled Intersection Appraisal Form. The sheet is separated into three areas: Identification, Physical Characteristics, and Performance Features. The first page of the appendix is a blank appraisal form with additional descriptive information about each category.

A Road Segment Appraisal Sheet was prepared and used to identify roadway characteristics in the study area. Study area streets were divided into segments with roughly equivalent lane characteristics for each of the pertinent study area streets. The form used for listing data has three sections: Identification, Section Characteristics and Functional Characteristics. The content of each section and item is self-evident. The Road Segment Appraisal Forms begin on page C-29.

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: _____

2 Intersection: _____

3 Route Nos: _____

4 Classification: Route type

5 Jurisdiction: assigns responsibility for maintenance of road

B. Physical Characteristics

B-1 Physical Features:

a. Sidewalks absence of existence

b. Curbing absence or existence

c. Parking Peak

d. Parking Off Peak

e. Approach Width width of the lane

f. Eff. Lane

g. Any Exclusive Turn Lanes absence or existence

h. Bus Stops existence

Approach #			
1	2	3	4

C. Performance Features:

C-1 Approach Vol. units - for all 4 approaches

Trucks Buses Pedest.
% % per hr.

1 number of vehicles percentage of trucks percentage of buses pedestrians per hour

2 _____

3 _____

4 _____

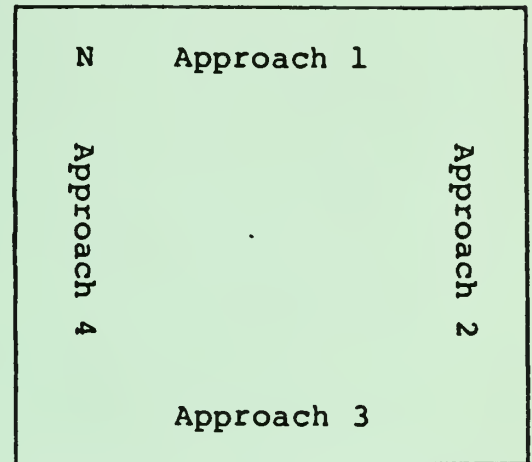
C-2 Int. Level of Service:

Peak _____

Off-peak _____

Schematic

B-2



B-3 Traffic Control Device:

Approach

1. _____

2. _____

3. _____

4. _____

Comments:

Any Additional Comments

C-3 Accident History

a. Time Period _____

b. # of accidents: _____

c. Accident rate/1M approach vehicles

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEWTON
 2 Intersection: NAHANTON ST @ WELLS AVE
 3 Route Nos: N/A
 4 Classification: UMA - Local
 5 Jurisdiction: CITY - UNACCEPTED

B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a	-	-	-	-
b. Curbing	b	L/R	L/R	L/R	L/R
c. Parking Peak	c	L/R	L/R	L/R	L/R
d. Parking Off Peak	d	L/R	L/R	L/R	L/R
e. Approach Width	e	19'-20"	17'-1"	18'-8"	
f. Eff. Lane	f	1	1	1	1
g. Any Exclusive Turn Lanes	g	-	-	-	-
h. Bus Stops	h	-	-	-	-

C. Performance Features:

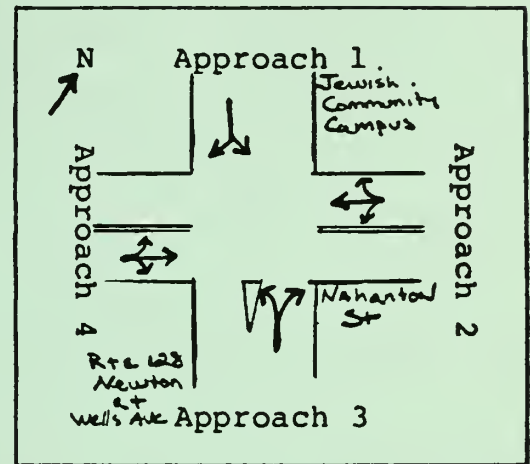
C-1 Approach Vol. units - VPH (PM Peak 9/84)		%		Pedest. per hr.
		Trucks	Buses	
1	<u>134</u>	<u>0.0</u>	<u>0</u>	<u>NA</u>
2	<u>638</u>	<u>0.47</u>	<u>0</u>	<u>NA</u>
3	<u>508</u>	<u>0.88</u>	<u>0</u>	<u>NA</u>
4	<u>718</u>	<u>0.42</u>	<u>0</u>	<u>NA</u>

C-2 Int. Level of Service:

Peak	PM	Left turns from #1	F
		Left turns from #2	A
		Left turns from #3	F
Off-peak	AM	Left turns from #1	F
		Left turns from #2	C
		Left turns from #3	F
	MID	Left turns from #1	D
		Left turns from #2	A
		Left turns from #3	F

Schematic

B-2



B-3 Traffic Control Device:

Approach

- NONE
- NONE
- NONE
- NONE

Comments:

C-3 Accident History

- Time Period _____
- # of accidents: NA
- Accident rate/1M approach vehicles _____

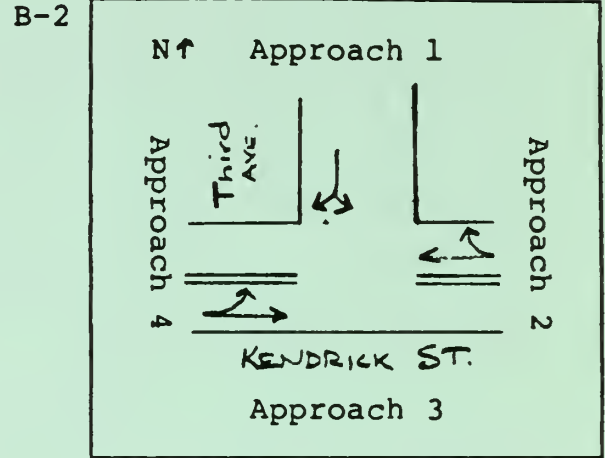
CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEEDHAM
 2 Intersection: Kendrick St @ Third Ave.
 3 Route Nos: N/A
 4 Classification: UMA - LOCAL
 5 Jurisdiction: TOWN - TOWN

Schematic



B. Physical Characteristics

B-1 Physical Features:

- a. Sidewalks
- b. Curbing
- c. Parking Peak
- d. Parking Off Peak
- e. Approach Width
- f. Eff. Lane
- g. Any Exclusive Turn Lanes
- h. Bus Stops

Approach #			
1	2	3	4
L/R	R		L/R
-	L/R		L/R
L/R	L/R		L/R
L/R	L/R		L/R
19.5'	20.0'		21.6'
1	1		1
-	-		-
-	-		-

B-3 Traffic Control Device:

Approach #

- 1. _____
- 2. NONE
- 3. NONE
- 4. NONE

Comments:

C. Performance Features:

C-1 Approach Vol. units -			
VPD (12/83)/			Pedest.
VPH (PM Peak 9/84)	Trucks	Buses	per hr.
1 <u>1900/523</u>	<u>3.25</u>	<u>0</u>	<u>NA</u>
2 <u>7075/1027</u>	<u>0.88</u>	<u>0</u>	<u>NA</u>
3 _____	_____	_____	_____
4 <u>7075/395</u>	<u>0.00</u>	<u>0</u>	<u>NA</u>

C-2 Int. Level of Service:

Peak PM: Left turns from #1 E
 Left turns from #4 A
 Left turns from #1 F
 Off-peak AM: Left turns from #1 A
 MID: Left turns from #1 C
 Left turns from #4 A

C-3 Accident History

- a. Time Period 1981-1983
- b. # of accidents: 12
- c. Accident rate/1M approach vehicles .68

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEEDHAM
 2 Intersection: Kendrick St @ Fourth Ave.
 3 Route Nos: N/A
 4 Classification: UMA - LOCAL
 5 Jurisdiction: TOWN - TOWN

B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a	R	L		R
b. Curbing	b	L/R	L		R
c. Parking Peak	c	L/R	L/R		L/R
d. Parking Off Peak	d	L/R	L/R		L/R
e. Approach Width	e	20'	18'-8"		20'-5"
f. Eff. Lane	f	1	1		1
g. Any Exclusive Turn Lanes	g	-	-		-
h. Bus Stops	h	-	-		-

C. Performance Features:

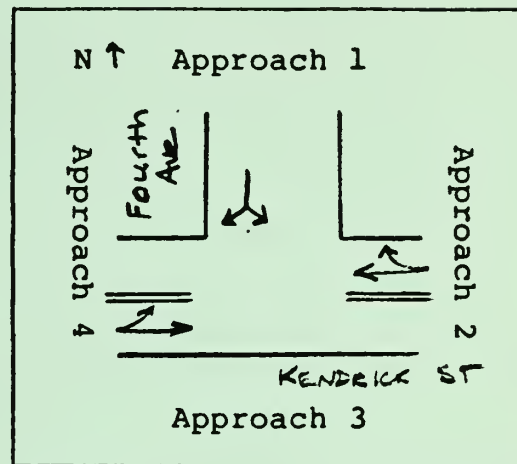
C-1 Approach Vol. units -				Pedest. per hr.
VPD (10/83)	#	Trucks	Buses	
1 <u>2750/402</u>		<u>2.49</u>	<u>0</u>	<u>NA</u>
2 <u>9400/1062</u>		<u>0.85</u>	<u>0</u>	<u>NA</u>
3 _____		_____	_____	_____
4 <u>9400/497</u>		<u>0.76</u>	<u>0</u>	<u>NA</u>

C-2 Int. Level of Service:

Peak PM: Lefts from #1 F
 Lefts from #4 A
 Off-peak AM: Lefts from #1 F
 Lefts from #4 A
 MID: Lefts from #1 D
 Lefts from #4 A

Schematic

B-2



B-3 Traffic Control Device:

Approach #

1. NONE
2. NONE
3. _____
4. NONE

Comments:

C-3 Accident History

- a. Time Period 1981 - 1983
- b. # of accidents: 16
- c. Accident rate/1M approach vehicles .68

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEEDHAM

2 Intersection: Kendrick St. @ Greendale Ave.

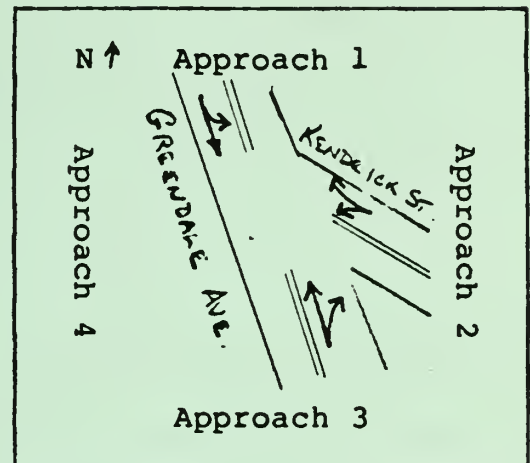
3 Route Nos: N/A

4 Classification: UMA - Collector

5 Jurisdiction: TOWN - TOWN

Schematic

B-2



B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a	L/R L	L/R		
b. Curbing	b	-	L/R	-	
c. Parking Peak	c	L/R L/R	L/R		
d. Parking Off Peak	d	L/R L/R	L/R		
e. Approach Width	e	17'	15'	14'	
f. Eff. Lane	f	1	1	1	
g. Any Exclusive Turn Lanes	g	-	-	-	
h. Bus Stops	h	-	-	-	

B-3 Traffic Control Device:

Approach

1. Flashing Yellow Blinkers
2. Flashing Yellow Blinker
3. STOP SIGN
4. _____

Comments:

C. Performance Features:

C-1 Approach Vol. units -

VPD (10/83)	%	Trucks	Buses	Pedest. per hr.
VPH (PM Peak 9/84)				
13250/308	1.30	0	NA	
22650/533	0.56	0	NA	
3600/54	1.85	0	NA	
4				

C-2 Int. Level of Service:

Peak PM: Left turns from #1 B
Left turns from #2 A

Off-peak AM: Left turns from #1 A
Left turns from #2 A

MID: Left turns from #1 A
Left turns from #2 A

C-3 Accident History

- a. Time Period 1981 - 1983
- b. # of accidents: undetermined
- c. Accident rate/1M approach vehicles

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEEDHAM

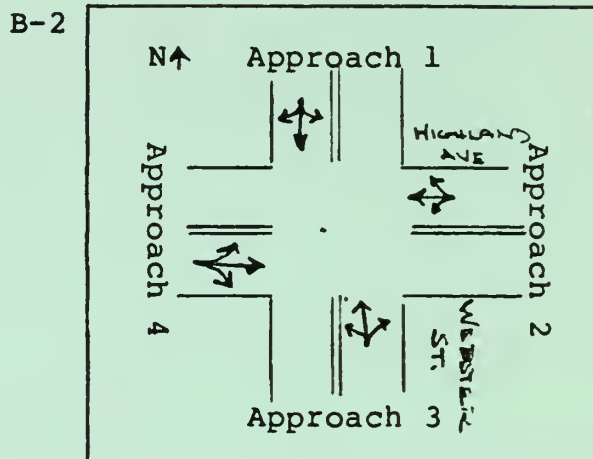
2 Intersection: HIGHLAND AVE @ WEBSTER ST.

3 Route Nos: N/A

4 Classification: OPA - COLLECTOR

5 Jurisdiction: MDPW - TOWN

Schematic



B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a	L/R	L/R	L/R	L/R
b. Curbing	b	L	R	L/R	L/R
c. Parking Peak	c	-	-	-	-
d. Parking Off Peak	d	-	-	-	-
e. Approach Width	e	13'	20'	22'	16'
f. Eff. Lane	f	1	1	1	1
g. Any Exclusive Turn Lanes	g	-	-	-	-
h. Bus Stops	h	-	-	-	-

B-3 Traffic Control Device:

Approach

1. Semi Actuated Signal
2. Semi Actuated Signal
3. Semi Actuated Signal
4. Semi Actuated Signal

Comments:

- Parking Restrictions not posted on approach 1 & 2 traffic operations don't permit parking
- Vehicles queue in two lanes on approach 1 & 2 and 3

C. Performance Features:

C-1 Approach Vol. units	%		Pedest.
VPD (9/83)	Trucks	Buses	per hr.
1 <u>3,375/460</u>	<u>0.43</u>	<u>0</u>	<u>NA</u>
2 <u>12,350/1009</u>	<u>1.78</u>	<u>0</u>	<u>NA</u>
3 <u>3,150/303</u>	<u>0.99</u>	<u>0</u>	<u>NA</u>
4 <u>8,000/521</u>	<u>2.30</u>	<u>0</u>	<u>NA</u>

C-2 Int. Level of Service:

Peak PM: C* V/C = .71

Off-peak AM: A V/C = .45

MID: A V/C = .43

* Left turn failure on Highland Ave WB

C-3 Accident History

- Time Period 1981 - 1983
- # of accidents: 42
- Accident rate/1M approach vehicles 1.43

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEEDHAM

2 Intersection: HIGHLAND AVE Gould St & Hunting Rd.

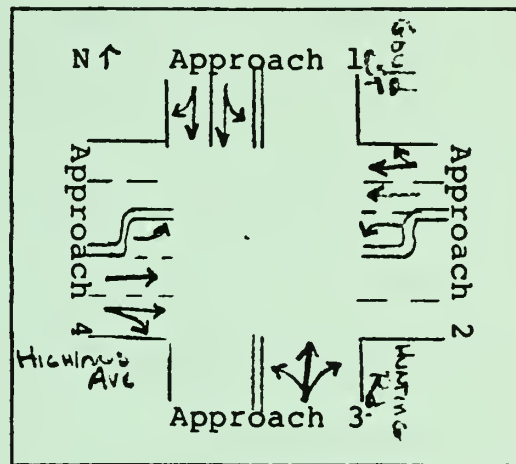
3 Route Nos: N/A

4 Classification: OPA-UMA-UMA

5 Jurisdiction: MDFW-TOWN-TOWN

Schematic

B-2



B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a	L/R	L/R	L/R	L/R
b. Curbing	b	L/R	L/R	L/R	L/R
c. Parking Peak	c	-	-	-	-
d. Parking Off Peak	d	-	-	-	-
e. Approach Width	e	22' 34'	16'	34'	
f. Eff. Lane	f	2	2	1	2
g. Any Exclusive Turn Lanes	g	-	L	-	L
h. Bus Stops	h	-	-	-	-

B-3 Traffic Control Device:

Approach

1. ACTUATED SIGNAL
2. ACTUATED SIGNAL
3. ACTUATED SIGNAL
4. ACTUATED SIGNAL

Comments:

- PARKING RESTRICTIONS NOT POSTED ON Gould St or Hunting Rd. Operating conditions do not permit parking on either approach.

C. Performance Features:

C-1 Approach Vol. units -

VPD (10/83)/		Trucks	Buses	Pedest. per hr.
VPH (PM PK. 9/84)				
1 10,606* / 738	1.22	0	NA	
2 9,850 / 1708	2.05	0	NA	
3 5,050 / 339	1.47	0	NA	
4 12,350 / 822	2.07	0	NA	

C-2 Int. Level of Service:

Peak PM : D V/C = .82

Off-peak AM : C V/C = .69

MD : B V/C = .58

* VPD (8/84); Vanasse / Hangen Assoc.

C-3 Accident History

- a. Time Period 1981 - 1983
- b. # of accidents: 57
- c. Accident rate/1M approach vehicles 1.30

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEEDHAM

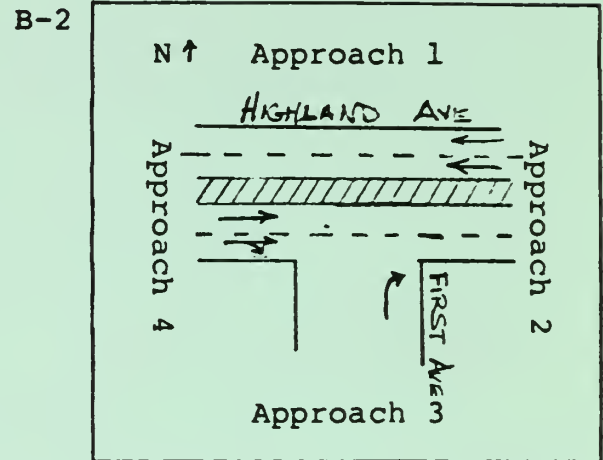
2 Intersection: HIGHLAND AVE @ FIRST AVE

3 Route Nos: N/A

4 Classification: OPA - LOCAL

5 Jurisdiction: MDPW - TOWN

Schematic



B. Physical Characteristics

B-1 Physical Features:

- a. Sidewalks
- b. Curbing
- c. Parking Peak
- d. Parking Off Peak
- e. Approach Width
- f. Eff. Lane
- g. Any Exclusive Turn Lanes
- h. Bus Stops

Approach #			
1	2	3	4
	-	R	R
	L/R	L/R	L/R
	-	R	-
	-	R	-
	24'	25'	39'
	2	1	2
	-	-	-
	-	-	-

B-3 Traffic Control Device:

Approach

1. _____
2. NONE
3. STOP SIGN
4. NONE

Comments:

C. Performance Features:

C-1 Approach Vol. units -

VPD (10/83) / VPH (PM PK 9/84)	% Trucks	Buses	Pedest. per hr.
1 _____	_____	_____	_____
2 <u>16,500 / 2238</u>	<u>NA</u>	<u>0</u>	<u>5</u>
3 <u>3,160 / 208</u>	<u>0.0</u>	<u>0</u>	<u>7</u>
4 <u>23,050 / 1148</u>	<u>4.79</u>	<u>0</u>	<u>NA</u>

C-2 Int. Level of Service:

Peak PM: No left turns permitted

Off-peak AM: No left turns permitted

MID: No left turns permitted

C-3 Accident History

- a. Time Period 1981 - 1983
- b. # of accidents: 25
- c. Accident rate/1M approach vehicles .80

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEEDHAM

2 Intersection: HIGHLAND AVE @ WEXFORD ST.

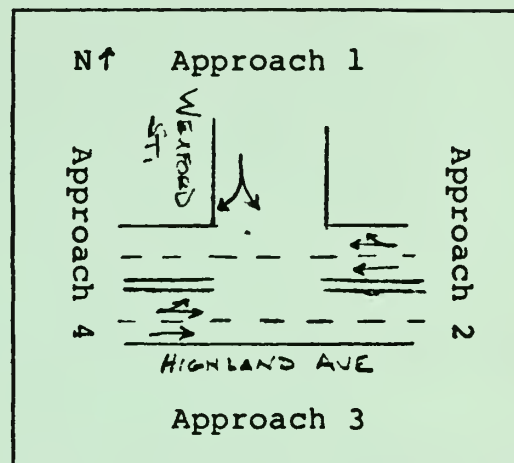
3 Route Nos: N/A

4 Classification: OPA - LOCAL

5 Jurisdiction: MDPW - TOWN

Schematic

B-2



B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a	-	L/R		L/R
b. Curbing	b	-	-		-
c. Parking Peak	c	L/R	-		-
d. Parking Off Peak	d	L/R	-		-
e. Approach Width	e	14' 26'			27'
f. Eff. Lane	f	1	2		2
g. Any Exclusive Turn Lanes	g	-	-		-
h. Bus Stops	h	-	-		-

B-3 Traffic Control Device:

Approach

1. NONE
2. NONE
3.
4. NONE

Comments:

PARKING RESTRICTIONS POSTED approx 100' from intersection of Wexford St - Violators observed 7/7/84 - No other parking restrictions posted

C. Performance Features:

C-1 Approach Vol. units -				Pedest.
VPD (10/83)/		Trucks	Buses	per hr.
1 <u>2500*/247</u>	8	1.62	0	NA
2 <u>16,500/1999</u>		2.00	0	NA
3 <u></u>				
4 <u>16,500/993</u>		3.48	0	NA

C-2 Int. Level of Service:

Peak PM: Left from #1 F
 Left from #4 E

Off-peak AM: Left from #1 F
 Left from #4 E

MID: Left from #1 F
 Left from #4 C

C-3 Accident History

a. Time Period 1981-1983

b. # of accidents: 75

c. Accident rate/1M approach vehicles 1.92

* Estimate

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEEDHAM

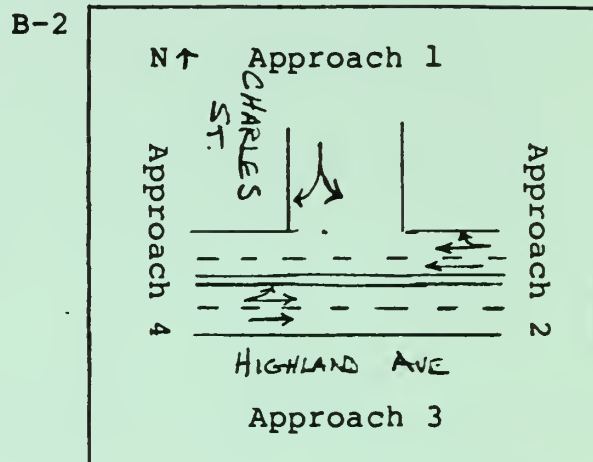
2 Intersection: HIGHLAND AVE @ CHARLES ST.

3 Route Nos: N/A

4 Classification: OPA - LOCAL

5 Jurisdiction: MDPV - TOWN

Schematic



B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a	-	L/R		L/R
b. Curbing	b	-	-		-
c. Parking Peak	c	L/R	-		-
d. Parking Off Peak	d	L/R	-		-
e. Approach Width	e	16'	24'		24'
f. Eff. Lane	f	1	2		2
g. Any Exclusive Turn Lanes	g	-	-		-
h. Bus Stops	h	-	-		-

B-3 Traffic Control Device:

Approach

1. _____
2. NONE
3. NONE
4. NONE

Comments:

C. Performance Features:

C-1 Approach Vol. units -

VPD (Oct. '83)	% Trucks	Buses	Pedest. per hr.
1 _____	_____	_____	_____
2 <u>16,500</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
3 <u>1,250*</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
4 <u>16,500</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>

C-2 Int. Level of Service:

Peak NA

Off-peak NA

C-3 Accident History

- Time Period 1981-1983
- # of accidents: 11
- Accident rate/1M approach vehicles .30

* Estimate used for analysis

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEEDHAM

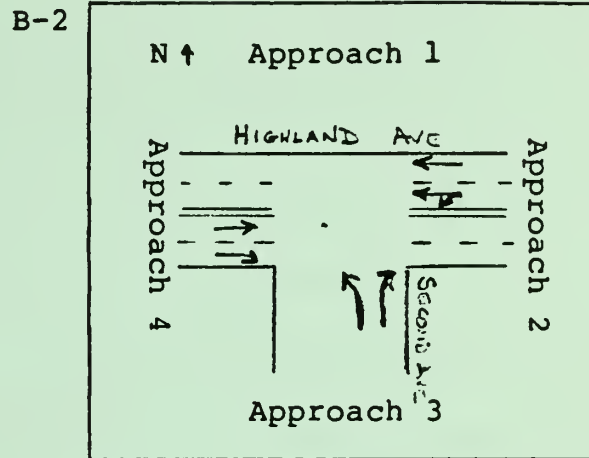
2 Intersection: HIGHLAND AVE @ SECOND AVE

3 Route Nos: N/A

4 Classification: OPA - LOCAL

5 Jurisdiction: MDPW - TOWN

Schematic



B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a		L/R	R	L/R
b. Curbing	b		L/R	R	L/R
c. Parking Peak	c		-	L/R	-
d. Parking Off Peak	d		-	L/R	-
e. Approach Width	e		26'	24'	24'
f. Eff. Lane	f		1	2	2
g. Any Exclusive Turn Lanes	g		R	-	-
h. Bus Stops	h		-	-	-

B-3 Traffic Control Device:

Approach

1. _____
2. Actuated SIGNAL
3. Actuated SIGNAL
4. Actuated SIGNAL

Comments:

- PARKING restrictions NOT posted on either side of SECOND AVE approach. Operating conditions do not permit parking.

C. Performance Features:

C-1 Approach Vol. units -

VPD (10/83) / 8 Pedest. per hr.

VPH (PM PK 9/84) Trucks Buses

1	_____	_____	_____
2	<u>13,350/1071</u>	<u>1.59</u>	<u>0</u>
3	<u>7,175/955</u>	<u>1.47</u>	<u>6</u>
4	<u>16,504/976</u>	<u>3.38</u>	<u>0</u>

C-2 Int. Level of Service:

Peak PM: F V/C = 1.02

Off-peak AM: C V/C = .77

MID: C V/C = .67

C-3 Accident History

- Time Period 1981-1982
- # of accidents: 53
- Accident rate/1M approach vehicles 1.30

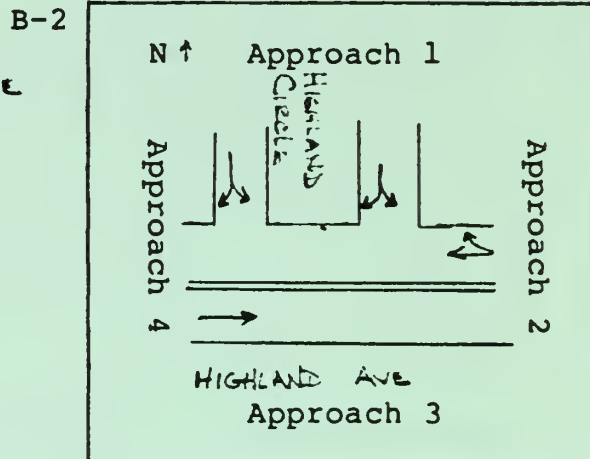
CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEEDHAM
 2 Intersection: HIGHLAND AVE @ HIGHLAND Circle
 3 Route Nos: N/A
 4 Classification: OPA - LOCAL
 5 Jurisdiction: MDFW - UNACCIDENTED

Schematic



B. Physical Characteristics

B-1 Physical Features:

- a. Sidewalks
- b. Curbing
- c. Parking Peak
- d. Parking Off Peak
- e. Approach Width
- f. Eff. Lane
- g. Any Exclusive Turn Lanes
- h. Bus Stops

Approach #			
1	2	3	4
-	-		-
-	L/R		L/R
L/R	-		-
L/R	-		-
9'ca	17'		19'
1	1		1
-	-		-
-	-		-

B-3 Traffic Control Device:

Approach #

- 1. NONE
- 2. NONE
- 3.
- 4. NONE

C. Performance Features:

C-1 Approach Vol. units -
 VPD (Oct. 1983)

	Trucks	Buses	Pedest. per hr.
1 <u>1254</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
2 <u>13,550</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
3 <u></u>	<u></u>	<u></u>	<u></u>
4 <u>13,550</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>

C-2 Int. Level of Service:

Peak NA
 Off-peak NA

Comments:

Angle Park driveways about Highland Circle throughout. Horse trailers observed using surface width for long term parking

C-3 Accident History

- a. Time Period 1981-1983
- b. # of accidents: 6
- c. Accident rate/1M approach vehicles .20

* Estimate used for analysis

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEEDHAM

2 Intersection: HIGHLAND AVE @ HIGHLAND TERR.

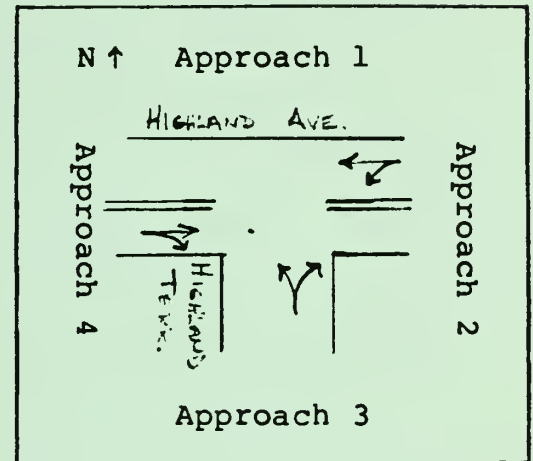
3 Route Nos: N/A

4 Classification: OPA - LOCAL

5 Jurisdiction: MDPW - UNACCIDENTED

Schematic

B-2



B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a		-	L/R	-
b. Curbing	b		L/R	-	L/R
c. Parking Peak	c		-	L/R	-
d. Parking Off Peak	d		-	L/R	-
e. Approach Width	e		19'	13'	19'
f. Eff. Lane	f		1	1	1
g. Any Exclusive Turn Lanes	g		-	-	-
h. Bus Stops	h		-	-	-

B-3 Traffic Control Device:

Approach

1. _____
2. NOISE
3. NOISE
4. NOISE

Comments:

C. Performance Features:

C-1 Approach Vol. units - VPD (10/83)

	Trucks	Buses	Pedest. per hr.
1 _____	_____	_____	_____
2 <u>13,550</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
3 <u>125*</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
4 <u>13,550</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>

C-2 Int. Level of Service:

Peak NA

Off-peak NA

C-3 Accident History

- a. Time Period 1981 - 1983
- b. # of accidents: 4
- c. Accident rate/lm approach vehicles .13

* Estimate used for analysis

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEEDHAM

2 Intersection: HIGHLAND AVE @ RIVERSIDE ST.

3 Route Nos: N/A

4 Classification: OPA - LOCAL

5 Jurisdiction: MDPW - TOWN

B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a		-	L/R	-
b. Curbing	b		L/R	-	L/R
c. Parking Peak	c		-	R	-
d. Parking Off Peak	d		-	R	-
e. Approach Width	e		19'	12'	19'
f. Eff. Lane	f		1	1	1
g. Any Exclusive Turn Lanes	g		-	-	-
h. Bus Stops	h		-	-	-

C. Performance Features:

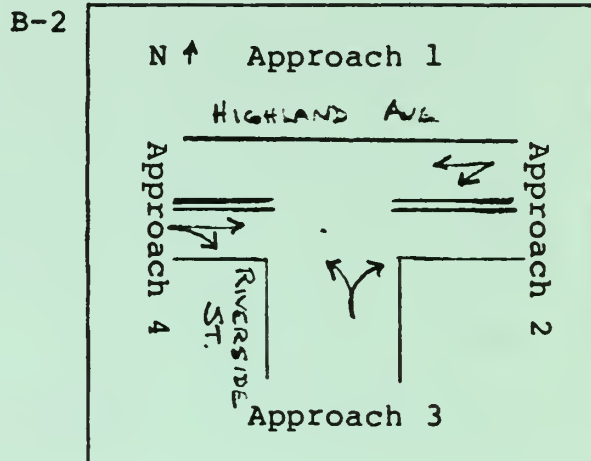
C-1 Approach Vol. units - VPD (10/83)	%		Pedest. per hr.
	Trucks	Buses	
1			
2 <u>13550</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
3 <u>125*</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
4 <u>13550</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>

C-2 Int. Level of Service:

Peak NA

Off-peak NA

Schematic



B-3 Traffic Control Device:

Approach

1. _____
2. NONE
3. NONE
4. NONE

Comments:

Riverside St leftside is footwalk thru
Angle park driveway directly abutting
road right-of-way

C-3 Accident History

- Time Period 1981-1983
- # of accidents: 5
- Accident rate/lm approach vehicles
.17

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEWTON

2 Intersection: NEEDHAM ST @ CHRISTINA ST @ OAK ST

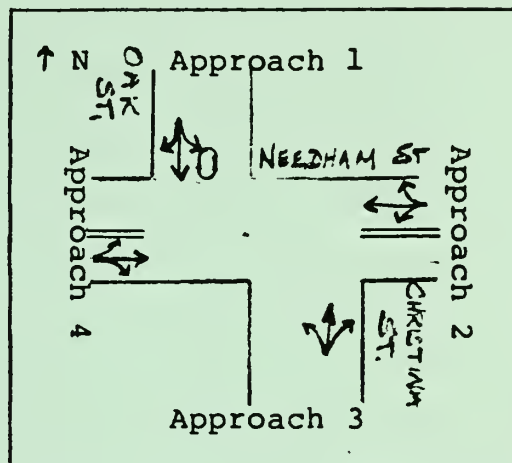
3 Route Nos: N/A

4 Classification: OPA - Local - Collector

5 Jurisdiction: MDPW - CITY - CITY

Schematic

B-2



B. Physical Characteristics

B-1 Physical Features:

a. Sidewalks

b. Curbing

c. Parking Peak

d. Parking Off Peak

e. Approach Width

f. Eff. Lane

g. Any Exclusive Turn Lanes

h. Bus Stops

Approach #			
1	2	3	4
L/R	L/R	-	-
L/R	L/R	-	L/R
L	-	R	-
L	-	R	-
17'	22'	11'	14.5'
1	1	1	1
-	-	-	-
-	-	-	-

B-3 Traffic Control Device:

Approach #

- NONE
- NONE
- NONE
- NONE

C. Performance Features:

C-1 Approach Vol. units -			
VPD (10/83)/	8		Pedest.
VPH (PM Peak 4/84)	Trucks	Buses	per hr.
1 3,750/258	1.16	0	NA
2 14,025/1070	2.52	0	NA
3 1,175/206	0.97	0	NA
4 13,550/1006	2.29	0	NA

C-2 Int. Level of Service:

Peak PM: Left from #1 F
Left from #3 F

Off-peak AM: Left from #1 F
Left from #3 F

MID: Left from #1 F
Left from #3 F

Comments:

- Newton Police direct traffic mon. fri 4:30pm - 5:45pm
- Parking is unrestricted on Christina St - vehicles observed on right side on dirt should.
- "No Parking" signs observed on right side of Oak St. - Signs apparently missing close to intersection

C-3 Accident History

a. Time Period 1981 - 1983

b. # of accidents: 63

c. Accident rate/lm approach vehicles 1.8

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEWTON

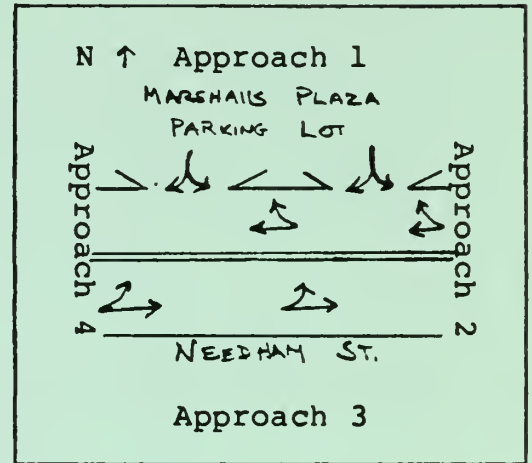
2 Intersection: NEEDHAM ST @ MARSHALL'S PLAZA

3 Route Nos: N/A

4 Classification: OPA

5 Jurisdiction: MDPW - PRIVATE

Schematic



B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a	-	R		L
b. Curbing	b	L/2	-/R		L/2
c. Parking Peak	c	-	-		-
d. Parking Off Peak	d	-	-		-
e. Approach Width	e	12'	21'		21'
f. Eff. Lane	f	2	-		-
g. Any Exclusive Turn Lanes	g	-	-		-
h. Bus Stops	h	-	-		-

B-3 Traffic Control Device:

Approach #

1. STOP SIGN
2. NONE
3.
4. NONE

Comments:

C. Performance Features:

C-1 Approach Vol. units -
VPD (10/83)

		Trucks	Buses	Pedest. per hr.
1	<u>NA</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
2	<u>14,025</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
3	<u></u>	<u></u>	<u></u>	<u></u>
4	<u>14,025</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>

C-2 Int. Level of Service:

Peak NA

Off-peak NA

C-3 Accident History

- a. Time Period 1981-1983
- b. # of accidents: 46
- c. Accident rate/lm approach vehicles

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEWTON

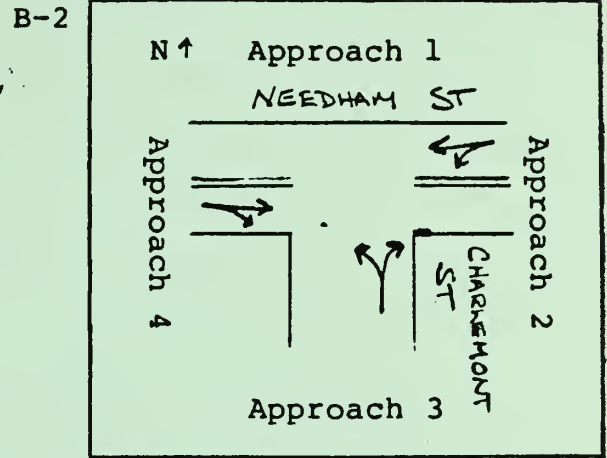
2 Intersection: Needham St. @ Charlemont St.

3 Route Nos: N/A

4 Classification: OPA - Local

5 Jurisdiction: MDPW - City

Schematic



B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a		L/R -	L/R	
b. Curbing	b		L/R -	L/R	
c. Parking Peak	c		-	L	-
d. Parking Off Peak	d		-	L	-
e. Approach Width	e		21'	15'	21'
f. Eff. Lane	f		1	1	1
g. Any Exclusive Turn Lanes	g		-	-	-
h. Bus Stops	h		-	-	-

B-3 Traffic Control Device:

Approach #

1. _____
2. NONE
3. NONE
4. NONE

Comments:

Parking unrestricted on Charlemont St
 Angle park & driveway about on right side
 vehicles observed on road surface
 unable to fit into spaces 7/9

C. Performance Features:

C-1 Approach Vol. units -
VPD (10/83)

	<u>% Trucks</u>	<u>Buses</u>	<u>Pedest. per hr.</u>
1 _____	_____	_____	_____
2 <u>14,025</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
3 <u>175*</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
4 <u>14,025</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>

C-2 Int. Level of Service:

Peak NA

Off-peak NA

C-3 Accident History

- a. Time Period 1981-1983
- b. # of accidents: 10
- c. Accident rate/1M approach vehicles
.32

* Estimate used for analysis

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. IdentificationA-1 Municipality: NEWTON2 Intersection: NEEDHAM ST @ BAYBANK & BOSTON FISH HOUSE3 Route Nos: N/A4 Classification: OPA5 Jurisdiction: MDPW - PRIVATEB. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a	-	R		L
b. Curbing	b	L/R	L/R		L/R
c. Parking Peak	c	-	-		-
d. Parking Off Peak	d	-	-		-
e. Approach Width	e	10'	19'		19'
f. Eff. Lane	f	1	1		1
g. Any Exclusive Turn Lanes	g	-	-		-
h. Bus Stops	h	-	-		-

C. Performance Features:C-1 Approach Vol. units -
VPD (10/83)

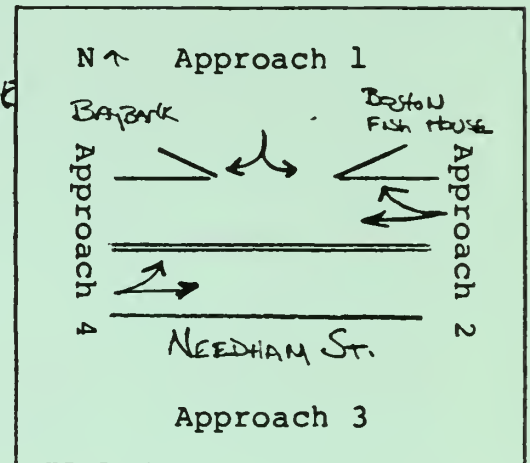
		Trucks	Buses	Pedest. per hr.
1	NA	NA	NA	NA
2	11,425	NA	NA	NA
3				
4	11,425	NA	NA	NA

C-2 Int. Level of Service:

Peak NAOff-peak NA

Schematic

B-2



B-3 Traffic Control Device:

Approach

1. NONE
2. NONE
3.
4. NONE

Comments:

C-3 Accident History

- a. Time Period 1981-1983
- b. # of accidents: 23
- c. Accident rate/lm approach vehicles

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEWTON

2 Intersection: NEEDHAM ST @ INDUSTRIAL PL.

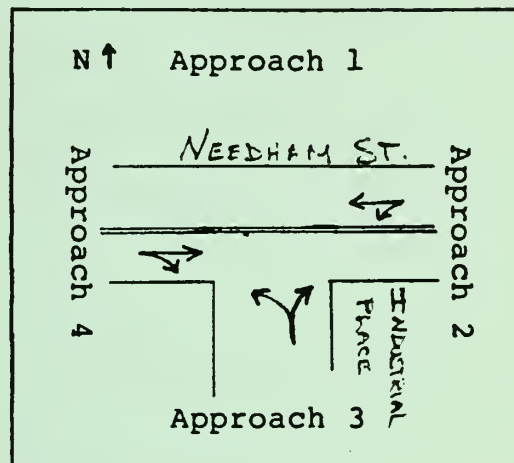
3 Route Nos: N/A

4 Classification: OPA - LOCAL

5 Jurisdiction: MDPW - CITY

Schematic

B-2



B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a		L/R	-	L/R
b. Curbing	b		L/R	-	L/R
c. Parking Peak	c		-	-	-
d. Parking Off Peak	d		-	-	-
e. Approach Width	e		19'	14'	19'
f. Eff. Lane	f		1	1	1
g. Any Exclusive Turn Lanes	g		-	-	-
h. Bus Stops	h		-	-	-

B-3 Traffic Control Device:

Approach

1. _____
2. NONE
3. NONE
4. NONE

Comments:

- Parking unrestricted on Industrial Pl. - angle park driveways abut road

C. Performance Features:

C-1 Approach Vol. units -

	VPD (4/83)	% Trucks	Buses	Pedest. per hr.
1	_____	_____	_____	_____
2	<u>14,025</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
3	_____	<u>NA</u>	<u>NA</u>	<u>NA</u>
4	<u>14,025</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>

C-2 Int. Level of Service:

Peak NA

Off-peak NA

C-3 Accident History

- a. Time Period 1981 - 1983
- b. # of accidents: 0
- c. Accident rate/1M approach vehicles 0

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEWTON

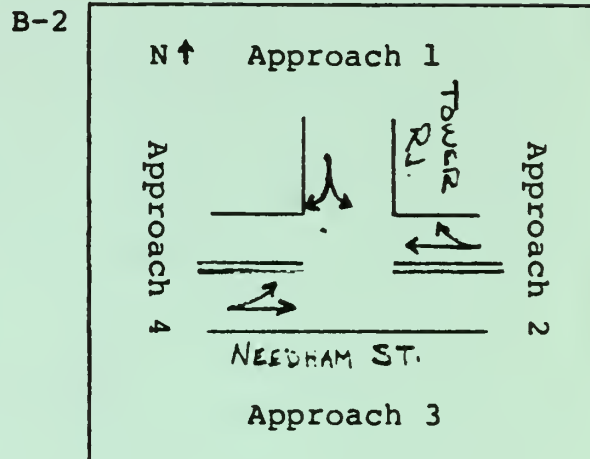
2 Intersection: NEEDHAM ST @ TOWER RD.

3 Route Nos: N/A

4 Classification: OPA - LOCAL

5 Jurisdiction: MDPW - UNACCEPTED

Schematic



B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a	L/R	L/R		L/R
b. Curbing	b	L/R	L/R		L/R
c. Parking Peak	c	-	-		-
d. Parking Off Peak	d	-	-		-
e. Approach Width	e	14' 20'	20'		20'
f. Eff. Lane	f	1	1		1
g. Any Exclusive Turn Lanes	g	-	-		-
h. Bus Stops	h	-	-		-

B-3 Traffic Control Device:

Approach

1. NONE
2. NONE
3.
4. NONE

Comments:

Parking violations observed on Tower Rd.
both sides 7/9/84 at 4:55pm

C. Performance Features:

C-1 Approach Vol. units -

VPD (10/83)/ VPH (PM Peak 9/84)	Trucks	Buses	Pedest. per hr.
1 <u>NA/106</u>	<u>4.72</u>	<u>0</u>	<u>1</u>
2 <u>14,025/869</u>	<u>1.27</u>	<u>0</u>	<u>1</u>
3 <u></u>	<u></u>	<u></u>	<u></u>
4 <u>14,025/1064</u>	<u>1.07</u>	<u>0</u>	<u>2</u>

C-2 Int. Level of Service:

Peak PM: Left from #1 E

Off-peak AM: Left from #1 E

MID: Left from #1 E

C-3 Accident History

- Time Period 1981-1983
- # of accidents: 11
- Accident rate/LM approach vehicles 36

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEWTON

2 Intersection: NEEDHAM ST @ JACONNET ST.

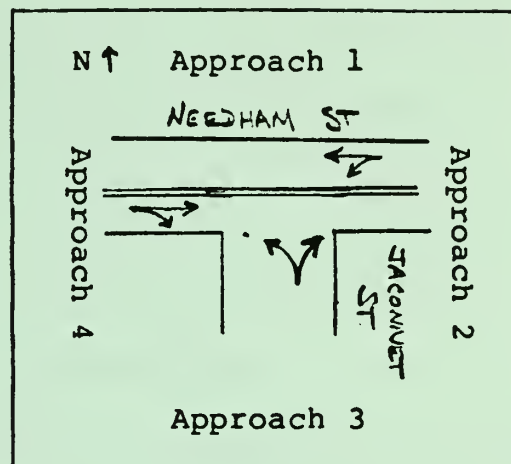
3 Route Nos: N/A

4 Classification: OPA - LOCAL

5 Jurisdiction: MDPW - CITY

Schematic

B-2



B. Physical Characteristics

B-1 Physical Features:

Approach #				
	1	2	3	4
a. Sidewalks	a	L/R -	L/R	
b. Curbing	b	L/R -	L/R	
c. Parking Peak	c	-	L/R -	
d. Parking Off Peak	d	-	L/R -	
e. Approach Width	e	18.5'	15'	18'
f. Eff. Lane	f	1	1	1
g. Any Exclusive Turn Lanes	g	-	-	-
h. Bus Stops	h	-	-	-

B-3 Traffic Control Device:

Approach

1. _____
2. NONE
3. NONE
4. NONE

Comments:

Parking observed on both sides of Jacomet St
7/9/84

C. Performance Features:

C-1 Approach Vol. units -

VPD (10/83)	% Trucks	Buses	Pedest. per hr.
1 _____	_____	_____	_____
2 <u>11,425</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
3 <u>175*</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
4 <u>14,025</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>

C-2 Int. Level of Service:

Peak NA

Off-peak NA

C-3 Accident History

- a. Time Period 1981-1983
- b. # of accidents: 5
- c. Accident rate/lm approach vehicles .18

* Estimate used for analysis

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEWTON

2 Intersection: NEEDHAM ST & ROCKLAND ST.

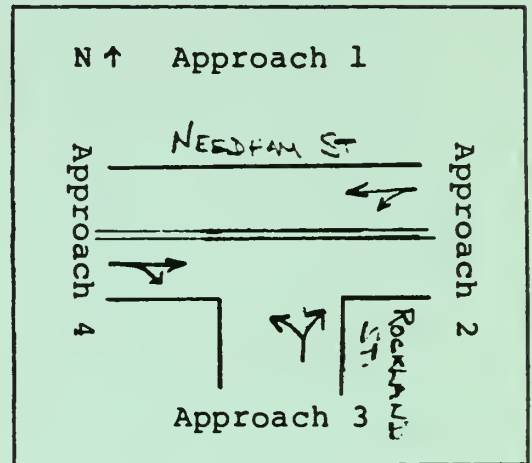
3 Route Nos: N/A

4 Classification: OPA - LOCAL

5 Jurisdiction: MDPW - CITY

Schematic

B-2



B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a		L/R	-	L/R
b. Curbing	b		L/R	-	L/R
c. Parking Peak	c		-	L/R	-
d. Parking Off Peak	d		-	L/R	-
e. Approach Width	e		19'	14'	18.5'
f. Eff. Lane	f		1	1	1
g. Any Exclusive Turn Lanes	g		-	-	-
h. Bus Stops	h		-	-	-

B-3 Traffic Control Device:

Approach #

1. _____
2. NONE
3. NONE
4. NONE

Comments:

Parking observed on both sides of Rockland St
7/9/84

C. Performance Features:

C-1 Approach Vol. units -
VPD (10/83)

	%		Pedest.
	Trucks	Buses	per hr.
1 _____	_____	_____	_____
2 <u>11,425</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
3 <u>NA</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
4 <u>11,425</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>

C-2 Int. Level of Service:

Peak NA

Off-peak NA

C-3 Accident History

- Time Period 1981-1983
- # of accidents: 0
- Accident rate/1M approach vehicles 0

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEWTON

2 Intersection: NEEDHAM ST @ Columbia Rd.

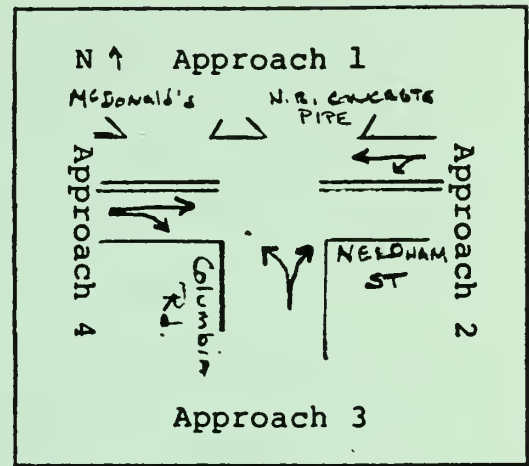
3 Route Nos: N/A

4 Classification: OPA - LOCAL

5 Jurisdiction: MDPW - CITY

Schematic

B-2



B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a		L/R	L/R	L
b. Curbing	b		L/R	L/R	L/R
c. Parking Peak	c		-	R	-
d. Parking Off Peak	d		-	R	-
e. Approach Width	e		19'	12'	19'
f. Eff. Lane	f		1	1	1
g. Any Exclusive Turn Lanes	g		-	-	-
h. Bus Stops	h		-	-	-

B-3 Traffic Control Device:

Approach #

1. _____
2. NONE
3. NONE
4. NONE

Comments:

- Driveway obliterated sidewalk on approach #4 - right side
- Left sidewalk on approach #3 used for parking by restaurant patrons

C. Performance Features:

C-1 Approach Vol. units - VPD (10/83)

	% Trucks	Buses	Pedest. per hr.
1 _____	_____	_____	_____
2 <u>11,400</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
3 <u>175</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>
4 <u>11,425</u>	<u>NA</u>	<u>NA</u>	<u>NA</u>

C-2 Int. Level of Service:

Peak NA

Off-peak NA

C-3 Accident History

- a. Time Period 1981-1983
- b. # of accidents: 24
- c. Accident rate/lm approach vehicles .95

CENTRAL TRANSPORTATION PLANNING STAFF

INTERSECTION APPRAISAL FORM

A. Identification

A-1 Municipality: NEWTON
 2 Intersection: NEEDHAM ST @ WINCHESTER ST & DEDHAM ST.
 3 Route Nos: N/A
 4 Classification: OPA - OPA - UMA
 5 Jurisdiction: MDPW - MDPW - CITY

B. Physical Characteristics

B-1 Physical Features:

		Approach #			
		1	2	3	4
a. Sidewalks	a	R	R	-	L/R
b. Curbing	b	R	L/R	-	L/R
c. Parking Peak	c	-	R	L/R	-
d. Parking Off Peak	d	-	R	L/R	-
e. Approach Width	e	21'	16'	16'	56'
f. Eff. Lane	f	1	1	1	1
g. Any Exclusive Turn Lanes	g	-	-	-	-
h. Bus Stops	h	-	-	-	-

C. Performance Features:

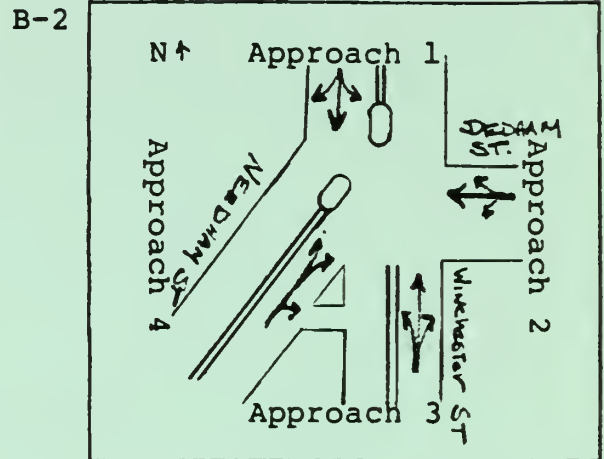
C-1 Approach Vol. units -

VPD (10/83)/ VPH (PM Peak 9/84)	Trucks	Buses	Pedest. per hr.
1 <u>12,725/1010</u>	<u>1.98</u>	<u>1</u>	<u>1</u>
2 <u>3,175/171</u>	<u>0.58</u>	<u>0</u>	<u>9</u>
3 <u>2,422/251</u>	<u>0.0</u>	<u>0</u>	<u>0</u>
4 <u>11,400/1136</u>	<u>0.62</u>	<u>0</u>	<u>2</u>

C-2 Int. Level of Service:

Peak PM:	Lefts from #1	F
	Lefts from #3	F
	Lefts from #4	E
Off-peak AM:	Lefts from #1	F
	Lefts from #3	F
	Lefts from #4	D
MID:	Lefts from #1	F
	Lefts from #3	F
	Lefts from #4	C

Schematic



B-3 Traffic Control Device:

Approach

- Yellow Flashing Beacon
- STOP SIGN / RED Flashing Beacon
- STOP SIGN / RED Flashing Beacon
- Yellow Flashing Beacon

Comments:

C-3 Accident History

- Time Period 1981-1983
- # of accidents: 53
- Accident rate/1M approach vehicles 1.63

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Newton
Street Name	:	Needham St.
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	M.D.P.W.
Functional Class	:	Other Principal Arterial
From	:	Winchester Street
To	:	Columbia Avenue
Length	:	.23M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	60 ft.
Surface Width	:	40 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left n	Right n
Curbing	Left x	Right x
Parking	Left n	Right n
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	22800
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.F.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Newton
Street Name	:	Needham St.
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	M.D.F.W.
Functional Class	:	Other Principal Arterial
From	:	Columbia Avenue
To	:	Christina St. & Oak St.
Length	:	.52M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	60 ft.
Surface Width	:	40 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left 4'	Right 3'
Curbing	Left x	Right x
Parking	Left n	Right n
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	28050
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Newton
Street Name	:	Needham St.
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	M.D.P.W.
Functional Class	:	Other Principal Arterial
From	:	Christina St. & Oak St.
To	:	Needham Town Line
Length	:	.07M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	60 ft.
Surface Width	:	40 ft.
Shoulder Width	Left 0 Right 0	
Median Width	:	0 ft.
Sidewalks	Left n Right n	
Curbing	Left x Right x	
Parking	Left n Right n	
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	27100
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Newton
Street Name	:	Winchester Street
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	M.D.F.W.
Functional Class	:	Other Principal Arterial
From	:	Needham Street
To	:	Columbia Road
Length	:	.11M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	42 ft.
Shoulder Width	Left 0	Right 2'
Median Width	:	0 ft.
Sidewalks	Left n	Right n
Curbing	Left n	Right n
Parking	Left x	Right x
Terrain	:	Rolling

Functional Characteristics

Existing A.D.T.	:	4800
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Newton
Street Name	:	Dedham Street
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	City
Functional Class	:	Urban Minor Arterial
From	:	Winchester Street
To	:	Stoney Brae Road
Length	:	.27M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	34 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left 5'	Right n
Curbing	Left x	Right x
Parking	Left x	Right x
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	6350
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.F.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Newton
Street Name	:	Columbia Road
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	City
Functional Class	:	Local
From	:	Needham Street
To	:	Winchester Street
Length	:	.11M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	24 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left 5'	Right 5'
Curbing	Left x	Right x
Parking	Left x	Right n
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	350
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Newton
Street Name	:	Rockland Street
Route Number	:	n/a
Federal Aid Sys.	:	Non-Federal Aid
Administrative Sys.	:	City
Functional Class	:	Local
From	:	Kenneth Street
To	:	Needham Street
Length	:	.04M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	28 ft.
Shoulder Width	Left 2' Right 2'	
Median Width	:	0 ft.
Sidewalks	Left n Right n	
Curbing	Left n Right n	
Parking	Left x Right x	
Terrain	:	Rolling

Functional Characteristics

Existing A.D.T.	:	n/a
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Newton
Street Name	:	Jaconnet Street
Route Number	:	n/a
Federal Aid Sys.	:	Non-Federal Aid
Administrative Sys.	:	City
Functional Class	:	Local
From	:	Dead End
To	:	Needham Street
Length	:	.12M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	30 ft.
Shoulder Width	Left 0	Right 2'
Median Width	:	0 ft.
Sidewalks	Left n	Right n
Curbing	Left n	Right n
Parking	Left x	Right x
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:
Total Accidents	:
Accidents/Road Mile	:
Accidents/MVM	:
Level of Service	:

C.T.F.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Newton
Street Name	:	Tower Road
Route Number	:	n/a
Federal Aid Sys.	:	Non-Federal Aid
Administrative Sys.	:	Unaccepted
Functional Class	:	Local
From	:	Needham Street
To	:	Cul-de-sac
Length	:	.12M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	29 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left 5'	Right 5'
Curbing	Left x	Right x
Parking	Left n	Right n
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	n/a
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Newton
Street Name	:	Industrial Place
Route Number	:	n/a
Federal Aid Sys.	:	Non-Federal Aid
Administrative Sys.	:	City
Functional Class	:	Local
From	:	Needham Street
To	:	Dead End
Length	:	.12M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	30 ft.
Shoulder Width	Left 2' Right n	
Median Width	:	0 ft.
Sidewalks	Left n Right 8'	
Curbing	Left n Right n	
Parking	Left x Right x	
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:
Total Accidents	:
Accidents/Road Mile	:
Accidents/MVM	:
Level of Service	:

C.T.P.S.

-- ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Newton
Street Name	:	Charlemont Street
Route Number	:	n/a
Federal Aid Sys.	:	Non-Federal Aid
Administrative Sys.	:	City
Functional Class	:	Local
From	:	Needham Street
To	:	Dead End
Length	:	.14M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	30 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left n	Right n
Curbing	Left n	Right n
Parking	Left x	Right x
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:
Total Accidents	:
Accidents/Road Mile	:
Accidents/MVM	:
Level of Service	:

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Newton
Street Name	:	Christina Street
Route Number	:	n/a
Federal Aid Sys.	:	Non-Federal Aid
Administrative Sys.	:	City
Functional Class	:	Local
From	:	Needham Street
To	:	Railroad Tracks
Length	:	.20M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	18 ft.
Shoulder Width	Left 2' Right 0	
Median Width	:	0 ft.
Sidewalks	Left n Right n	
Curbing	Left n Right n	
Parking	Left x Right n	
Terrain	:	Rolling

Functional Characteristics

Existing A.D.T.	:	2350
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Newton
Street Name	:	Oak Street
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	City
Functional Class	:	Urban Collector
From	:	Needham Street
To	:	Chestnut Street
Length	:	.28M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	29 ft.
Shoulder Width	Left 0 Right 0	
Median Width	:	0 ft.
Sidewalks	Left 8' Right 8'	
Curbing	Left x Right x	
Parking	Left x Right x	(one hour restriction)
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	7500
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality : Needham
Street Name : Highland Circle
Route Number : n/a
Federal Aid Svs. : Non-Federal Aid
Administrative Sys. : Unaccepted
Functional Class : Local
From : Highland Avenue
To : Highland Avenue
Length : .12M

Section Characteristics

Number of Lanes : 1
Divided : no
Layout/ROW Width : ft.
Surface Width : 18 ft.
Shoulder Width Left 0 Right 0
Median Width : 0 ft.
Sidewalks Left n Right n
Curbing Left n Right n
Parking Left x Right x
Terrain : Level

Functional Characteristics

Existing A.D.T. : n/a
Total Accidents :
Accidents/Road Mile :
Accidents/MVM :
Level of Service :

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Riverside Street
Route Number	:	n/a
Federal Aid Sys.	:	Non-Federal Aid
Administrative Sys.	:	Town
Functional Class	:	Local
From	:	Highview Street
To	:	Highland Avenue
Length	:	.18M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	23 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left 4'	Right 4'
Curbing	Left n	Right n
Parking	Left x	Right x
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	n/a
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Highview Street
Route Number	:	n/a
Federal Aid Sys.	:	Non-Federal Aid
Administrative Sys.	:	Unaccepted
Functional Class	:	Local
From	:	Highland Terrace
To	:	Riverside Street
Length	:	.05M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	16 ft.
Shoulder Width	Left 0 Right 0	
Median Width	:	0 ft.
Sidewalks	Left n Right n	
Curbing	Left n Right n	
Parking	Left x Right x	
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	n/a
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

-- ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality : Needham
Street Name : Highland Terrace
Route Number : n/a
Federal Aid Sys. : Non-Federal Aid
Administrative Svs. : Unaccepted
Functional Class : Local
From : Highland Avenue
To : Highview Street
Length : .21M

Section Characteristics

Number of Lanes : 1
Divided : no
Layout/ROW Width : ft.
Surface Width : 20 ft.
Shoulder Width Left 0 Right 0
Median Width : 0 ft.
Sidewalks Left 4' Right n
Curbing Left n Right n
Parking Left x Right x
Terrain : Level

Functional Characteristics

Existing A.D.T. : n/a
Total Accidents :
Accidents/Road Mile :
Accidents/MVM :
Level of Service :

C.T.F.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Charles Street
Route Number	:	n/a
Federal Aid Sys.	:	Non-Federal Aid
Administrative Sys.	:	Town
Functional Class	:	Local
From	:	Highland Avenue
To	:	Freemont Street
Length	:	.28M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	30 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left n	Right n
Curbing	Left n	Right n
Parking	Left x	Right x
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	n/a
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Wexford Street
Route Number	:	n/a
Federal Aid Sys.	:	Non-Federal Aid
Administrative Sys.	:	Town
Functional Class	:	Local
From	:	Freemont Street
To	:	Highland Avenue
Length	:	.26M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	30 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left n	Right n
Curbing	Left n	Right n
Parking	Left x	Right x
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	n/a
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.F.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Highland Avenue
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	M.D.F.W.
Functional Class	:	Other Principal Arterial
From	:	Newton City Line
To	:	Second Avenue
Length	:	.17M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	30 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left n	Right n
Curbing	Left x	Right x
Parking	Left n	Right n
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	27100
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Highland Avenue
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	M.D.F.W.
Functional Class	:	Other Principal Arterial
From	:	Second Avenue
To	:	First Avenue
Length	:	.14M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	32 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left 5'	Right 5'
Curbing	Left n	Right n
Parking	Left n	Right n
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	33000
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Highland Avenue
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	M.D.P.W.
Functional Class	:	Other Principal Arterial
From	:	First Avenue
To	:	Route 128
Length	:	.22M

Section Characteristics

Number of Lanes	:	4
Divided	:	yes
Layout/ROW Width	:	ft.
Surface Width	:	52 ft.
Shoulder Width	Left 0 Right 0	
Median Width	:	3 ft.
Sidewalks	Left 5' Right n	
Curbing	Left x Right x	
Parking	Left n Right n	
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	46100
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Highland Avenue
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	M.D.F.W.
Functional Class	:	Other Principal Arterial
From	:	Route 128
To	:	Southbound Ramp (west side)
Length	:	.19M

Section Characteristics

Number of Lanes	:	4
Divided	:	yes
Layout/ROW Width	:	ft.
Surface Width	:	52 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	3 ft.
Sidewalks	Left 5'	Right n
Curbing	Left x	Right x
Parking	Left n	Right n
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	39700
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Highland Avenue
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	M.D.P.W.
Functional Class	:	Other Principal Arterial
From	:	Southbound Ramp (west side)
To	:	Mills Road
Length	:	.14M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	29 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left 5'	Right 5'
Curbing	Left n	Right n
Parking	Left n	Right n
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	39700
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.F.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Highland Avenue
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	M.D.P.W.
Functional Class	:	Other Principal Arterial
From	:	Mills Road
To	:	Webster Street
Length	:	.15M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	29 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left 5'	Right 5'
Curbing	Left n	Right n
Parking	Left n	Right n
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	24700
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Second Avenue
Route Number	:	n/a
Federal Aid Sys.	:	Non-Federal Aid
Administrative Sys.	:	Town
Functional Class	:	Local
From	:	Fourth Avenue
To	:	Highland Avenue
Length	:	.44M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	40 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left 4'	Right n
Curbing	Left n	Right n
Parking	Left x	Right n
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	14350
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.F.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	First Avenue
Route Number	:	n/a
Federal Aid Svs.	:	Non-Federal Aid
Administrative Sys.	:	Town
Functional Class	:	Local
From	:	Highland Avenue
To	:	B Street
Length	:	.52M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	40 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left 4'	Right n
Curbing	Left n	Right n
Parking	Left x	Right x
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	7900
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Gould Street
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	Town
Functional Class	:	Urban Minor Arterial
From	:	Highland Avenue
To	:	Railroad Tracks
Length	:	.26M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Lavout/ROW Width	:	ft.
Surface Width	:	28 ft.
Shoulder Width	Left 0 Right 2'	
Median Width	:	0 ft.
Sidewalks	Left 4' Right n	
Curbing	Left x Right n	
Parking	Left x Right x	
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	n/a
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Hunting Road
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	Town
Functional Class	:	Urban Minor Arterial
From	:	Kendrick Street
To	:	Greendale Avenue
Length	:	.11M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	46 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left n	Right 4'
Curbing	Left x	Right x
Parking	Left x	Right x
Terrain	:	Rolling

Functional Characteristics

Existing A.D.T.	:	n/a
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Hunting Road
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	Town
Functional Class	:	Urban Minor Arterial
From	:	David Road
To	:	Kendrick Street
Length	:	.42M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	46 ft.
Shoulder Width	Left 2' Right 2'	
Median Width	:	0 ft.
Sidewalks	Left n Right 4'	
Curbing	Left n Right n	
Parking	Left x Right x	
Terrain	:	Rolling

Functional Characteristics

Existing A.D.T.	:	10450
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Hunting Road
Route Number	:	n/a
Federal Aid Sys.	:	Urban Svstems
Administrative Sys.	:	Town
Functional Class	:	Urban Minor Arterial
From	:	Highland Avenue
To	:	David Road
Length	:	.23M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	32 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left 4'	Right 4'
Curbing	Left x	Right x
Parking	Left x	Right x
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	10500
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.F.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Cross Street
Route Number	:	n/a
Federal Aid Sys.	:	Non-Federal Aid
Administrative Sys.	:	Unaccepted
Functional Class	:	Local
From	:	Highland Avenue
To	:	Putnam St.
Length	:	.12M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	16 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left n	Right n
Curbing	Left n	Right n
Parking	Left x	Right x
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	n/a
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Mills Road
Route Number	:	n/a
Federal Aid Sys.	:	Non-Federal Aid
Administrative Sys.	:	Town
Functional Class	:	Local
From	:	Highland Avenue
To	:	Sachem Road
Length	:	.09M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	24 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left 4'	Right n
Curbing	Left n	Right n
Parking	Left x	Right x
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	n/a
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Webster Street
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	Town
Functional Class	:	Urban Collector
From	:	Highland Avenue
To	:	Great Plain Avenue
Length	:	1.28M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Lavout/ROW Width	:	ft.
Surface Width	:	32 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left 4'	Right 4'
Curbing	Left x	Right x
Parking	Left x	Right x
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	6300
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

-- ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Greendale Avenue
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	Town
Functional Class	:	Urban Collector
From	:	High Street
To	:	Hunting Road
Length	:	.39M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	28 ft.
Shoulder Width	Left 0 Right 0	
Median Width	:	0 ft.
Sidewalks	Left 4' Right 4'	
Curbing	Left n Right n	
Parking	Left x Right x	
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	6500
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Greendale Avenue
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	Town
Functional Class	:	Urban Collector
From	:	Webster Street
To	:	High Street
Length	:	.27M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	24 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left 4'	Right 4'
Curbing	Left n	Right n
Parking	Left x	Right x
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	1750
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Webster Street
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	Town
Functional Class	:	Urban Collector
From	:	Hillside Avenue
To	:	Highland Avenue
Length	:	.20M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	22 ft.
Shoulder Width	Left 0 Right 0	
Median Width	:	0 ft.
Sidewalks	Left 4' Right 4'	
Curbing	Left n Right n	
Parking	Left x Right x	
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	6750
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.F.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality : Needham
Street Name : Kendrick Street
Route Number : n/a
Federal Aid Sys. : Urban Systems
Administrative Sys. : Town
Functional Class : Urban Minor Arterial
From : Greendale Avenue
To : Hunting Road
Length : .08M

Section Characteristics

Number of Lanes : 4
Divided : no
Layout/ROW Width : ft.
Surface Width : 27 ft.
Shoulder Width Left 0 Right 0
Median Width : 0 ft.
Sidewalks Left n Right 4'
Curbing Left x Right x
Parking Left x Right x
Terrain : Rolling

Functional Characteristics

Existing A.D.T. : n/a
Total Accidents :
Accidents/Road Mile :
Accidents/MVM :
Level of Service :

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Kendrick Street
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	Town
Functional Class	:	Urban Minor Arterial
From	:	Hunting Road
To	:	Route 128 Bridge
Length	:	.07M

Section Characteristics

Number of Lanes	:	4
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	40 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left n	Right 4'
Curbing	Left x	Right x
Parking	Left x	Right x
Terrain	:	Rolling

Functional Characteristics

Existing A.D.T.	:	14150
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Kendrick Street
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	M.D.P.W.
Functional Class	:	Urban Minor Arterial
From	:	Route 128 Bridge
To	:	Route 128 Bridge
Length	:	.06M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	40 ft.
Shoulder Width	Left 0 Right 0	
Median Width	:	0 ft.
Sidewalks	Left n Right 4'	
Curbing	Left x Right x	
Parking	Left n Right n	
Terrain	:	Rolling

Functional Characteristics

Existing A.D.T.	:	14150
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Kendrick Street
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	Town
Functional Class	:	Urban Minor Arterial
From	:	Route 128 Bridge
To	:	Third Avenue
Length	:	.18M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	40 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left n	Right n
Curbing	Left x	Right x
Parking	Left x	Right x
Terrain	:	Rolling

Functional Characteristics

Existing A.D.T.	:	14150
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Kendrick Street
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	Town
Functional Class	:	Urban Minor Arterial
From	:	Third Avenue
To	:	Fourth Avenue
Length	:	.05M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	40 ft.
Shoulder Width	Left 0 Right 0	
Median Width	:	0 ft.
Sidewalks	Left 4' Right n	
Curbing	Left x Right x	
Parking	Left x Right x	
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	18800
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Kendrick Street
Route Number	:	n/a
Federal Aid Sys.	:	Urban Systems
Administrative Sys.	:	Town
Functional Class	:	Urban Minor Arterial
From	:	Fourth Avenue
To	:	Newton City Line
Length	:	.28M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	40 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left n	Right n
Curbing	Left x	Right x
Parking	Left x	Right x
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	18800
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Third Avenue
Route Number	:	n/a
Federal Aid Sys.	:	Non-Federal Aid
Administrative Sys.	:	Town
Functional Class	:	Local
From	:	B Street
To	:	Kendrick Street
Length	:	.24M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	40 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left n	Right 4'
Curbing	Left n	Right n
Parking	Left x	Right x
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	3800
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

C.T.P.S.

ROAD SEGMENT APPRAISAL SHEET

*****-----*****

Identification

Municipality	:	Needham
Street Name	:	Fourth Avenue
Route Number	:	n/a
Federal Aid Sys.	:	Non-Federal Aid
Administrative Sys.	:	Town
Functional Class	:	Local
From	:	Kendrick Street
To	:	Second Avenue
Length	:	.44M

Section Characteristics

Number of Lanes	:	2
Divided	:	no
Layout/ROW Width	:	ft.
Surface Width	:	40 ft.
Shoulder Width	Left 0	Right 0
Median Width	:	0 ft.
Sidewalks	Left 6'	Right n
Curbing	Left x	Right x
Parking	Left x	Right x
Terrain	:	Level

Functional Characteristics

Existing A.D.T.	:	5500
Total Accidents	:	
Accidents/Road Mile	:	
Accidents/MVM	:	
Level of Service	:	

Appendix D

INTERSECTION LEVEL OF SERVICE ANALYSIS
(ASSUMPTIONS AND RESULTS)

Appendix D

Description of Content

Contained in this appendix are the results of the study area intersection turning movement count surveys conducted by CTPS in September and October of 1985. The peak hour turning movements are summarized for each of the intersections surveyed by peak hour during morning, midday and evening periods.

Following the turning movement count summaries are detailed worksheets of the level of service analysis prepared for each intersection. Circular 212 methods were used for the purpose of these analyses. Morning, midday and evening peak hour conditions were evaluated.

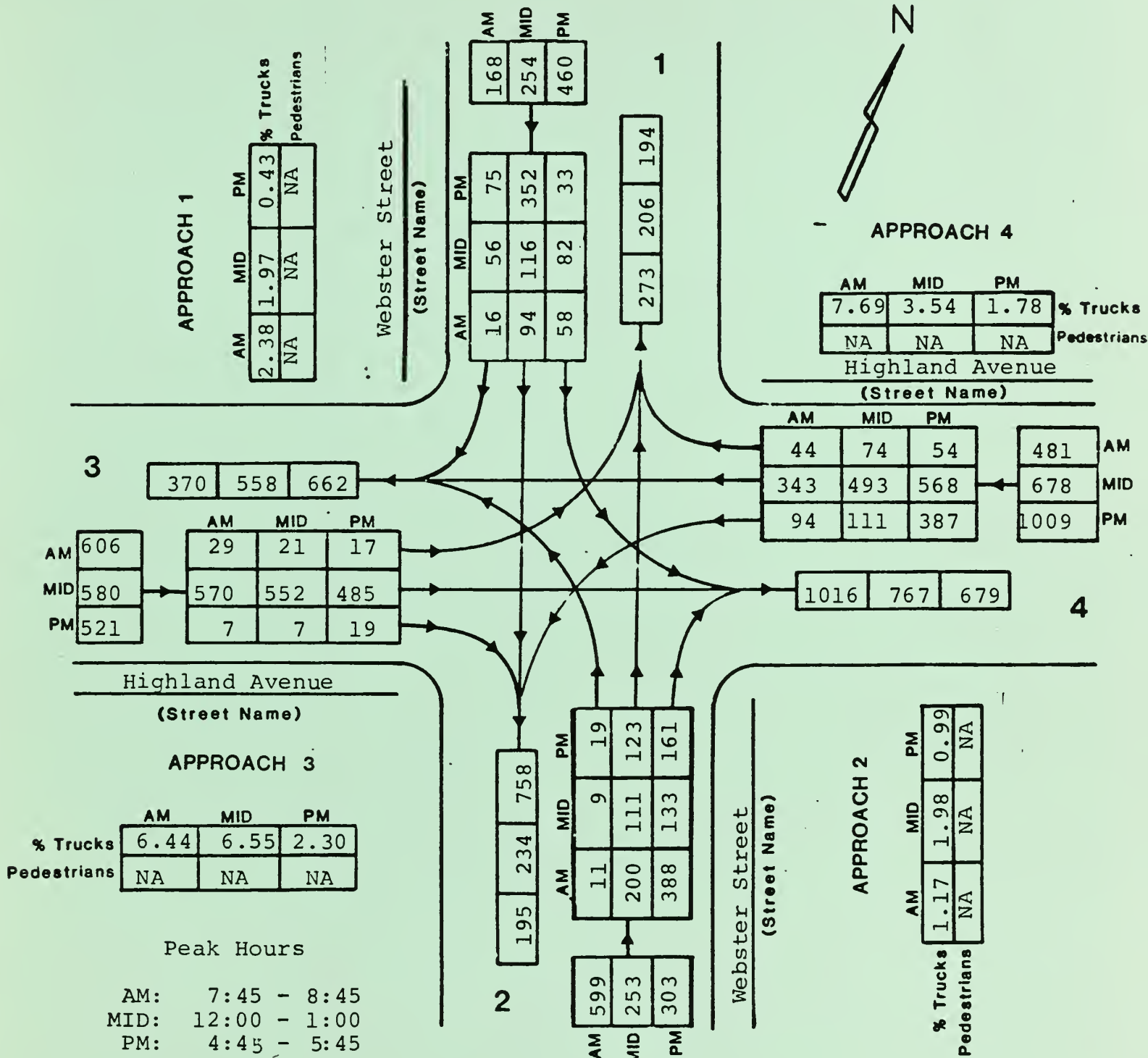
A peak hour level of service analysis completed for each of the following is included:

- Highland Avenue at Webster Street
- Highland Avenue at Gould Street and Hunting Road
- Highland Avenue at First Avenue
- Highland Avenue at Wexford Street
- Highland Avenue at Second Avenue
- Needham Street at Oak Street and Christina Street
- Needham Street at Tower Road
- Needham Street at Winchester Street and Dedham Street
- Winchester Street at Route 9 Eastbound On/Off Ramp
- Centre Street at Winchester Street and Route 9 Westbound On/Off Ramps
- Nahanton Street at Wells Avenue and the Jewish Community Campus
- Kendrick Street at Fourth Avenue
- Kendrick Street at Third Avenue
- Kendrick Street at Hunting Road
- Kendrick Street at Greendale Avenue
- Webster Street at Greendale Avenue

SUMMARY OF VEHICLE MOVEMENTS

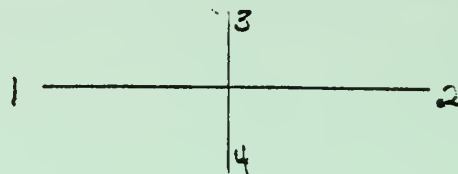
Intersection Highland Avenue @ Webster Street

Date 9-19-84 Day of Week Wednesday Weather Fair 65°F Community Needham



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

A.M. Sept. '84



STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Webster St.	Webster St.
#THRU LANES	2	2	1	2
AVG WIDTH	8	10	13	11
#LT LANES	0	0	0	0
AVG WIDTH	0	0	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	29	94	58	11
THRU VOL	570	343	94	200
RT VOL	7	44	16	388
PED VOL	10	10	10	10
TRUCK %	6.4	7.7	2.4	1.2
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	70	70	70	70
CHANGE INT	51	51	51	51
LT CAP ON CI	103	103	103	103
G/C	.50	.50	.49	.49
OP VOL	387	577	588	110
LT CAP ON GR	213	23	0	478
LT TOT CAP	316	126	103	581
LT VOL	29	94	58	11
PASS CHK	t	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.89	0.90	0.88	0.84
LT VOL	35	112	67	13
THRU VOL	681	410	109	241
RT VOL	8	53	19	467

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	387	577	588	110
PCE LTU	2.00	2.00	2.00	1.00
PCE LTP	1.20	1.20	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
A1B2	759	731
A2B1	688	598
A3B4	263	209
A4B3	722	724

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	567	559	244	172
PCE LTU	2.00	2.00	1.00	1.00
PCE LTP	1.20	1.20	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
A1B2	696	677
A2B1	918	814
A3B4	332	354
A4B3	340	342

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
A1B2	402	391
A2B1	482	427
A3B4	299	318
A4B3	178	180

STEP TEN OUTPUT

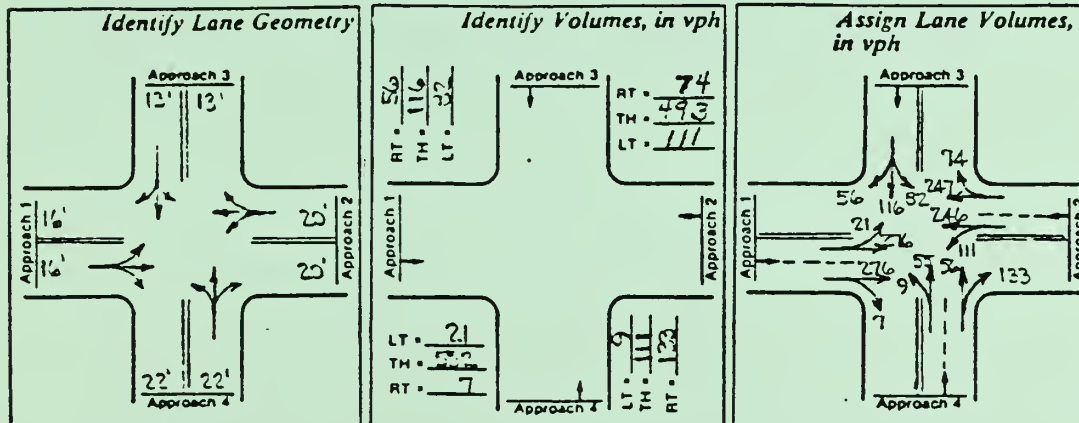
POSSIBLE PHASES APPROACHES 1 & 2

482	1-one phase only
818	8-two phases, directional split

POSSIBLE PHASES APPROACHES 3 & 4

299	1-one phase only
498	8-two phases, directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
Existing Condition → 1	1	0.43	781	1800	A
1	8	0.57	979	1720	B
8	1	0.65	1117	1720	B
8	8	0.80	1316	1650	D



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

MID Sept.'84

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Webster St.	Webster St.
#THRU LANES	2	2	1	2
AVG WIDTH	8	10	13	11
#LT LANES	0	0	0	0
AVG WIDTH	0	0	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	21	111	82	9
THRU VOL	552	493	116	111
RT VOL	7	74	56	133
FED VOL	10	10	10	10
TRUCK %	6.6	3.5	2.0	2.0
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	70	70	70	70
CHANGE INT	51	51	51	51
LT CAP ON CI	103	103	103	103
G/C	.57	.57	.42	.42
OP VOL	567	559	244	172
LT CAP ON GR	117	125	260	332
LT TOT CAP	220	228	363	435
LT VOL	21	111	82	9
PASS CHK	t	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.92	0.89	0.78	0.76
LT VOL	24	129	107	12
THRU VOL	640	573	152	149
RT VOL	8	86	73	179

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
A1B2	438	422
A2B1	361	314
A3B4	237	188
A4B3	379	380

STEP TEN OUTPUT

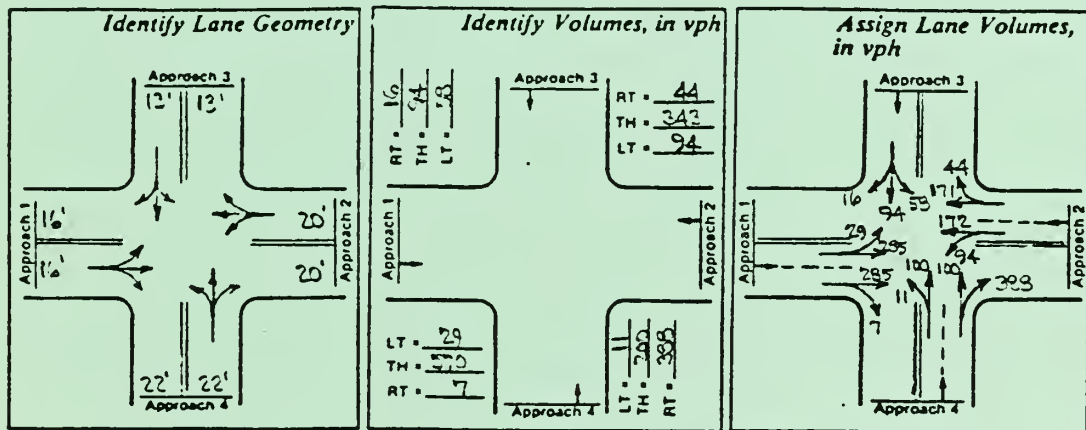
POSSIBLE PHASES APPROACHES 1 & 2

438	1-one phase only
736	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

379	1-one phase only
568	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
→ 1	1	0.45	817	1800	A
1	8	0.59	1007	1720	B
8	1	0.65	1115	1720	B
8	8	0.79	1305	1650	D



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

P.M. Sept. '84

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Webster St.	Webster St.
#THRU LANES	2	2	1	2
AVG WIDTH	8	10	13	11
#LT LANES	0	0	0	0
AVG WIDTH	0	0	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	17	387	33	19
THRU VOL	485	568	352	123
RT VOL	19	54	75	161
PED VOL	10	10	10	10
TRUCK %	2.3	1.8	0.4	1.0
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE (secs)	70	70	70	70
CHANGE INT	51	51	51	51
LT CAP ON CI	103	103	103	103
G/C	.52	.52	.47	.47
OP VOL	622	504	284	427
LT CAP ON GR	2	120	280	137
LT TOT CAP	105	223	383	240
LT VOL	17	387	33	19
PASS CHK	t	f	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.94	0.91	0.89	0.80
LT VOL	19	433	37	24
THRU VOL	528	635	397	155
RT VOL	21	60	85	203

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	622	504	284	427
PCE LTU	4.00	2.00	1.00	2.00
PCE LTP	1.20	1.20	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
A1B2	623	571
A2B1	1562	1215
A3B4	519	526
A4B3	407	387

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
A1B2	359	330
A2B1	820	638
A3B4	467	474
A4B3	213	203

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

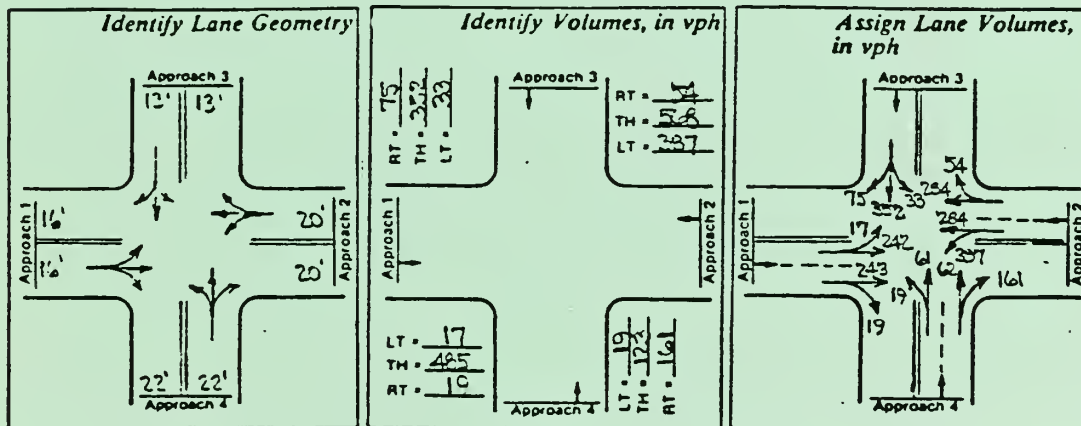
820	1-one phase only
968	8-two phases, directional split:

POSSIBLE PHASES APPROACHES 3 & 4

467	1-one phase only
677	8-two phases, directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
Existing Condition → 1*	1	0.71	1287	1800	C
8	1	0.83	1435	1720	D
1*	8	0.87	1497	1720	D
8	8	1.00	1645	1650	E

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

A.M. Install X Left on Highland Ave. WB

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Webster St.	Webster St.
#THRU LANES	2	1	1	2
AVG WIDTH	8	10	13	11
#LT LANES	0	1	0	0
AVG WIDTH	0	10	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	29	94	58	11
THRU VOL	570	343	94	200
RT VOL	7	44	16	388
PED VOL	10	10	10	10
TRUCK %	6.4	7.7	2.4	1.2
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	70	70	70	70
CHANGE INT	51	51	51	51
LT CAP ON CI	103	103	103	103
G/C	.56	.56	.43	.43
OP VOL	387	577	588	110
LT CAP ON GR	285	95	0	406
LT TOT CAP	388	198	103	509
LT VOL	29	94	58	11
PASS CHK	t	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.89	0.90	0.88	0.84
LT VOL	35	112	67	13
THRU VOL	681	410	109	241
RT VOL	8	53	19	467

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	387	577	588	110
PCE LTU	2.00	2.00	2.00	1.00
PCE LTP	1.20	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B1	225	118
A2	463	463
A1B2	759	731
A3B4	263	209
A4B3	722	724

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B1	225	118
A2	463	463
A1B2	438	422
A3B4	237	188
A4B3	379	380

STEP TEN OUTPUT

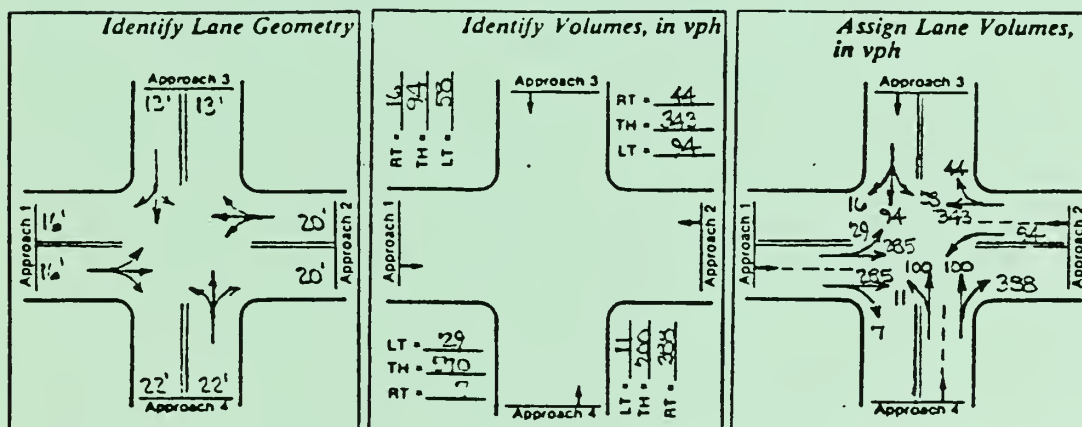
POSSIBLE PHASES APPROACHES 1 & 2

463	1-one phase only
581	2-two phase,one left protected,no overlap
557	3-two phases,one left protected,overlap
885	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

379	1-one phase only
568	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1	1	0.47	842	1800	A
3	1	0.54	935	1720	A
2	1	0.56	960	1720	A
1	8	0.60	1031	1720	B
3	8	0.68	1125	1650	C
2	8	0.70	1150	1650	C
8	1	0.74	1264	1720	C
8	8	0.88	1454	1650	D



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

MID Install X Left on Highland Ave. WB

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Webster St.	Webster St.
#THRU LANES	2	1	1	2
AVG WIDTH	8	10	13	11
#LT LANES	0	1	0	0
AVG WIDTH	0	10	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	21	111	82	9
THRU VOL	552	493	116	111
RT VOL	7	74	56	133
PED VOL	10	10	10	10
TRUCK %	6.6	3.5	2.0	2.0
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE (secs)	70	70	70	70
CHANGE INT	51	51	51	51
LT CAP ON CI	103	103	103	103
G/C	.69	.69	.30	.30
OP VOL	567	559	244	172
LT CAP ON GR	261	269	116	188
LT TOT CAP	364	372	219	291
LT VOL	21	111	82	9
PASS CHK	t	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.93	0.89	0.78	0.76
LT VOL	24	129	107	12
THRU VOL	633	573	152	149
RT VOL	8	86	73	179

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	567	559	244	172
PCE LTU	2.00	2.00	1.00	1.00
PCE LTP	1.20	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B1	258	136
A2	659	659
A1B2	689	670
A3B4	332	354
A4B3	340	342

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B1	258	136
A2	659	659
A1B2	398	387
A3B4	299	318
A4B3	178	180

STEP TEN OUTPUT

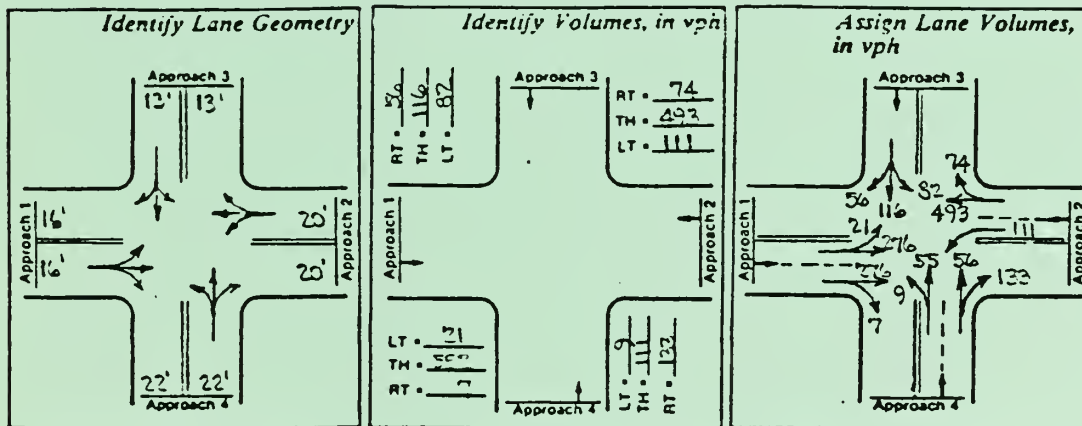
POSSIBLE PHASES APPROACHES 1 & 2

659	1-one phase only
795	2-two phase, one left protected, no overlap
659	3-two phases, one left protected, overlap
1046	8-two phases, directional split

POSSIBLE PHASES APPROACHES 3 & 4

299	1-one phase only
498	8-two phases, directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1	1	0.53	958	1800	A
3	1	0.56	958	1720	A
2	1	0.64	1094	1720	B
1	8	0.67	1157	1720	C
3	8	0.70	1157	1650	C
8	1	0.78	1345	1720	D
2	8	0.78	1293	1650	D
8	8	0.94	1544	1650	E



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

P.M. w/ xleft on Highland Ave W.T.

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Webster St.	Webster St.
#THRU LANES	2	1	1	2
AVG WIDTH	8	10	13	11
#LT LANES	0	1	0	0
AVG WIDTH	0	10	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	17	387	33	19
THRU VOL	485	568	352	123
RT VOL	19	54	75	161
PED VOL	10	10	10	10
TRUCK %	2.3	1.8	0.4	1.0
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	70	70	70	70
CHANGE INT	51	51	51	51
LT CAP ON CI	103	103	103	103
G/C	.57	.57	.42	.42
OP VOL	622	504	284	427
LT CAP ON GR	62	180	220	77
LT TOT CAP	165	283	323	180
LT VOL	17	387	33	19
PASS CHK	t	f	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.94	0.91	0.89	0.80
LT VOL	19	433	37	24
THRU VOL	528	635	397	155
RT VOL	21	60	85	203

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	622	504	284	427
PCE LTU	4.00	2.00	1.00	2.00
PCE LTP	1.20	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

UNPROTECT LT PROTECT LT

B1	866	455
A2	696	696
A1B2	623	571
A2B1	820	638
A3B4	519	526
A4B3	407	387

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B1	866	455
A2	696	696
A1B2	359	330
A2B1	820	638
A3B4	467	474
A4B3	213	203

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

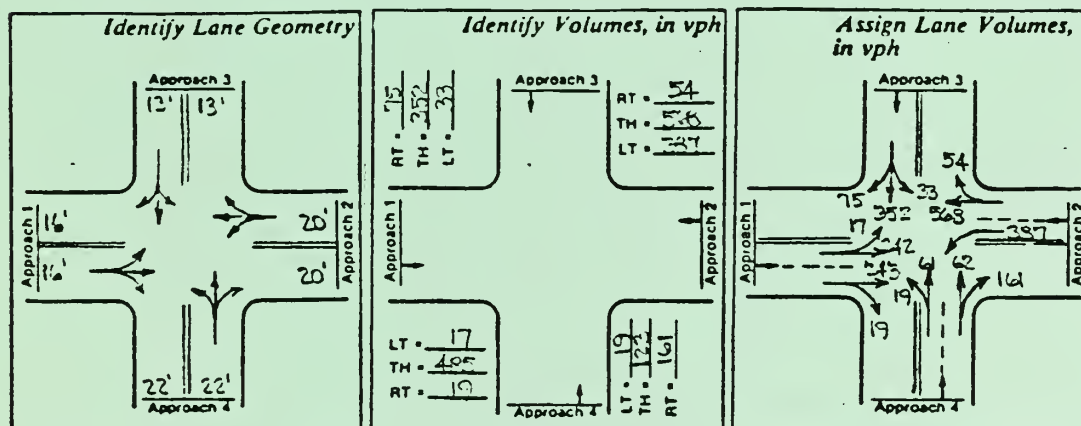
866	1-one phase only
1150	2-two phase,one left protected,no overlap
814	3-two phases,one left protected,overlap
1025	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

467	1-one phase only
677	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1*	1	0.74	1333	1800	C
3	1	0.74	1281	1720	C
8	1	0.87	1492	1720	D
1*	8	0.90	1543	1720	E
3	8	0.90	1491	1650	E
2	1	0.94	1617	1720	E
8	8	1.03	1702	1650	F
2	8	1.11	1827	1650	F

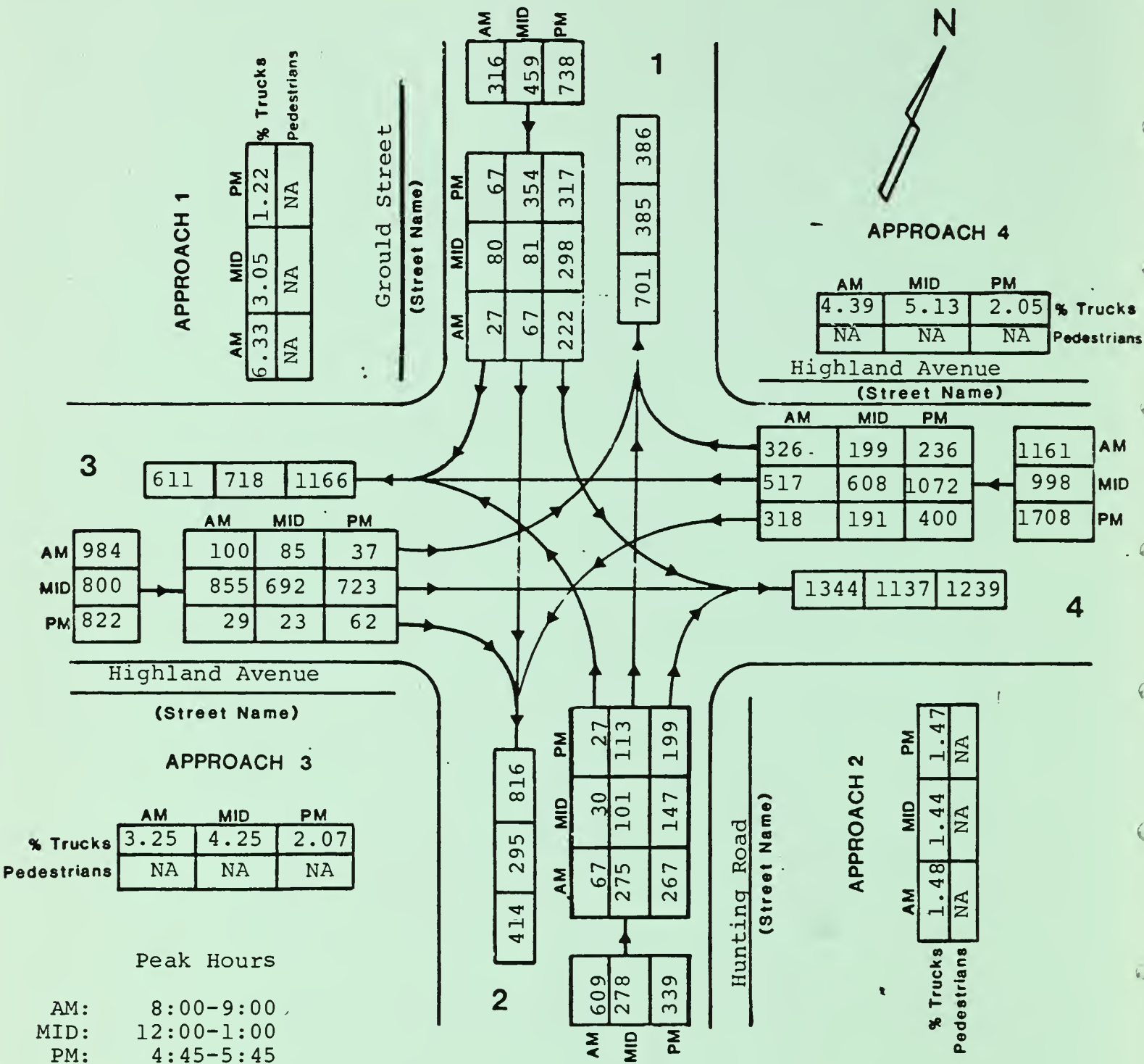
* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above



SUMMARY OF VEHICLE MOVEMENTS

Intersection Highland Avenue @ Gould Street & Hunting Road

Date 9-19-84 Day of Week Wednesday Weather Fair 65°F Community Needham



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

AM 9/84 ASSUME ELIMINATION OF HUNTING RD RIGHT TURN EFFECTS

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Gould St.	Hunting Rd.
#THRU LANES	2	2	2	2
AVG WIDTH	12	12	11	8
#LT LANES	1	1	0	0
AVG WIDTH	10	10	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	100	318	222	67
THRU VOL	855	517	67	275
RT VOL	29	326	27	0
PED VOL	5	5	5	5
TRUCK %	3.3	4.4	6.3	1.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	85	85	85	85
CHANGE INT	42	42	42	42
LT CAP ON CI	85	85	85	85
G/C	.72	.72	.27	.27
OP VOL	843	884	275	94
LT CAP ON GR	21	0	49	230
LT TOT CAP	106	85	134	315
LT VOL	100	318	222	67
PASS CHK	t	f	f	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.92	0.87	0.93	0.91
LT VOL	112	382	254	75
THRU VOL	960	620	77	307
RT VOL	33	391	31	0

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	843	884	275	94
PCE LTU	4.00	4.00	1.00	1.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B2	449	118
A1	993	993
B1	1526	401
A2	1012	1012
A3B4	361	412
A4B3	381	396

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B2	449	119
A1	521	521
B1	1526	401
A2	531	531
A3B4	190	216
A4B3	220	229

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

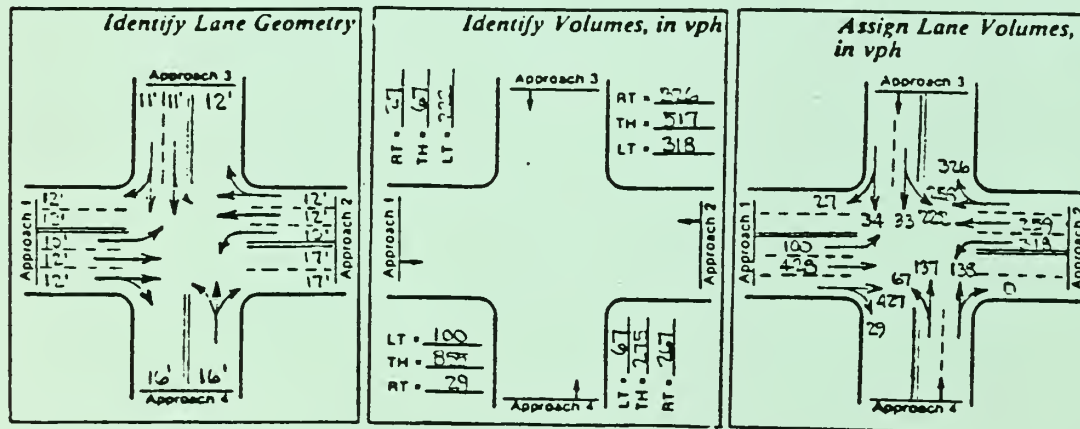
1526	1-one phase only
932	2-two phase,one left protected,no overlap
922	3-two phases,one left protected,overlap
932	4-two phases,both lefts protected,no overlap
922	5-three phases,both lefts protected,overlap
1050	6-three phases,lead/lag,no overlap
2048	7-three phases,lead/lag,overlap
1052	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

220	1-one phase only
445	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
3	1*	0.66	1142	1720	B
2	1*	0.67	1152	1720	B
4	1*	0.67	1152	1720	B
5	1*	0.69	1142	1650	C
8	1*	0.74	1272	1720	C
6	1*	0.77	1270	1650	C
5	8	0.83	1367	1650	D
3	8	0.83	1367	1650	D
4	8	0.83	1377	1650	D
2	8	0.83	1377	1650	D
6	8	0.91	1495	1650	E
8	8	0.91	1497	1650	E
1*	1*	0.97	1747	1800	E
1*	8	1.15	1972	1720	F
7	1*	1.37	2268	1650	F
7	8	1.51	2493	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

MID 9/84 ASSUME ELIMINATION OF HUNTING RD RIGHT TURN EFFECTS

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Gould St.	Hunting Rd.
#THRU LANES	2	2	2	2
AVG WIDTH	12	12	11	8
#LT LANES	1	1	0	0
AVG WIDTH	10	10	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	85	191	298	30
THRU VOL	692	608	81	101
RT VOL	23	199	80	0
PED VOL	5	5	5	5
TRUCK %	4.3	5.3	3.1	1.4
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	85	85	85	85
CHANGE INT	42	42	42	42
LT CAP ON CI	85	85	85	85
G/C	.63	.63	.36	.36
OP VOL	807	715	101	161
LT CAP ON GR	0	41	331	271
LT TOT CAP	85	126	416	356
LT VOL	85	191	298	30
PASS CHK	f	f	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.89	0.96	0.84	0.81
LT VOL	100	210	366	38
THRU VOL	811	667	99	126
RT VOL	27	218	98	0

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	807	715	101	161
PCE LTU	4.00	4.00	1.00	1.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

UNPROTECT LT PROTECT LT

B2	398	105
A1	838	838
B1	838	220
A2	885	885
A3B4	563	637
A4B3	164	172

	UNPROTECT LT	PROTECT LT
B2	398	105
A1	440	440
B1	838	220
A2	465	465
A3B4	296	334
A4B3	95	99

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

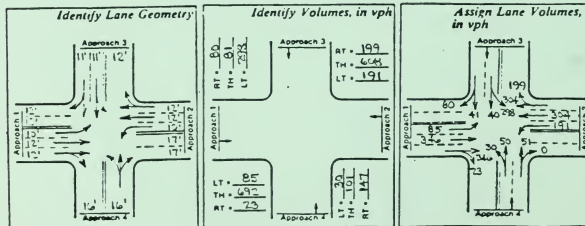
838	1-one phase only
685	2-two phase,one left protected,no overlap
660	3-two phases,one left protected,overlap
685	4-two phases,both lefts protected,no overlap
660	5-three phases,both lefts protected,overlap
789	6-three phases,lead/lag,no overlap
1278	7-three phases,lead/lag,overlap
905	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

296	1-one phase only
433	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
3*	1	0.56	956	1720	A
2*	1	0.57	980	1720	B
4	1	0.57	980	1720	B
5	1	0.58	956	1650	B
1*	1	0.63	1134	1800	B
6	1	0.66	1085	1650	B
5	8	0.66	1093	1650	B
3*	8	0.66	1093	1650	B
4	8	0.68	1118	1650	C
2*	8	0.68	1118	1650	C
8	1	0.70	1200	1720	C
1*	8	0.74	1271	1720	C
6	8	0.74	1223	1650	C
8	8	0.81	1338	1650	D
7	1	0.95	1574	1650	E
7	8	1.04	1711	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

PM 9/84 ASSUME ELIMINATION OF HUNTING RD RIGHT TURN EFFECTS

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Gould St.	Hunting Rd.
#THRU LANES	2	2	2	2
AVG WIDTH	12	12	11	8
#LT LANES	1	1	0	0
AVG WIDTH	10	10	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	37	400	317	27
THRU VOL	723	1072	354	114
RT VOL	62	236	67	0
FED VOL	5	5	5	5
TRUCK %	2.1	2.1	1.2	1.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	85	85	85	85
CHANGE INT	42	42	42	42
LT CAP ON CI	85	85	85	85
G/C	.63	.63	.36	.36
OP VOL	1308	785	114	421
LT CAP ON GR	0	0	318	11
LT TOT CAP	85	85	403	96
LT VOL	37	400	317	27
PASS CHK	t	f	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.90	0.95	0.90	0.84
LT VOL	42	430	356	33
THRU VOL	820	1152	398	138
RT VOL	70	254	75	0

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	1308	785	114	421
PCE LTU	6.00	4.00	1.00	2.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

UNPROTECT LT

PROTECT LT

B2	252	44
A1	891	891
B1	1720	451
A2	1406	1406
A3B4	830	901
A4B3	203	177

	UNPROTECT LT	PROTECT LT
B2	252	44
A1	468	468
B1	1720	451
A2	738	738
A3B4	436	473
A4B3	117	102

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

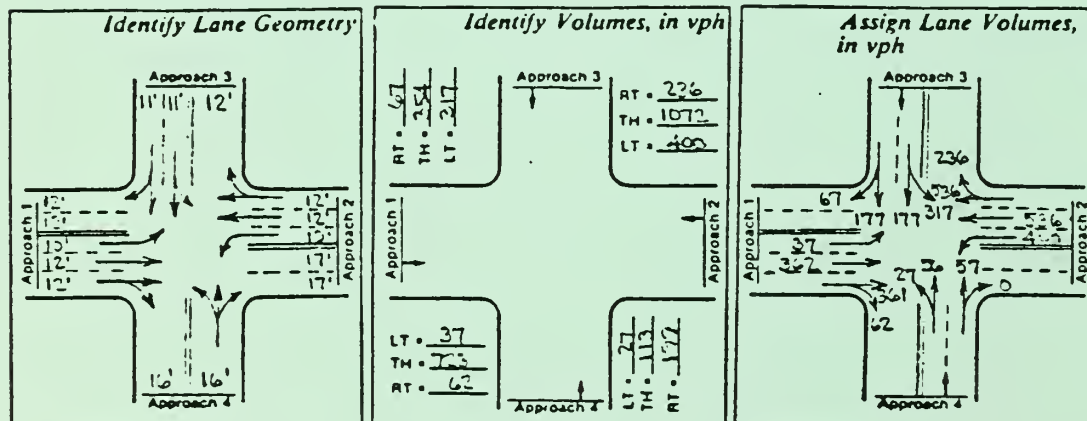
1720	1-one phase only
1189	2-two phase,one left protected,no overlap
919	3-two phases,one left protected,overlap
1189	4-two phases,both lefts protected,no overlap
919	5-three phases,both lefts protected,overlap
1233	6-three phases,lead/lag,no overlap
2187	7-three phases,lead/lag,overlap
1206	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

436	1-one phase only
575	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
3	1	0.79	1355	1720	D
5	1	0.82	1355	1650	D
5	8	0.91	1494	1650	E
3	8	0.91	1494	1650	E
4	1	0.94	1625	1720	E
2	1	0.94	1625	1720	E
8	1	0.95	1641	1720	E
6	1	1.01	1669	1650	F
4	8	1.07	1765	1650	F
2	8	1.07	1765	1650	F
8	8	1.08	1781	1650	F
6	8	1.10	1809	1650	F
1*	1	1.20	2155	1800	F
1*	8	1.33	2295	1720	F
7	1	1.59	2623	1650	F
7	8	1.67	2762	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above



SUMMARY OF VEHICLE MOVEMENTS

Intersection Highland Avenue @ First Avenue

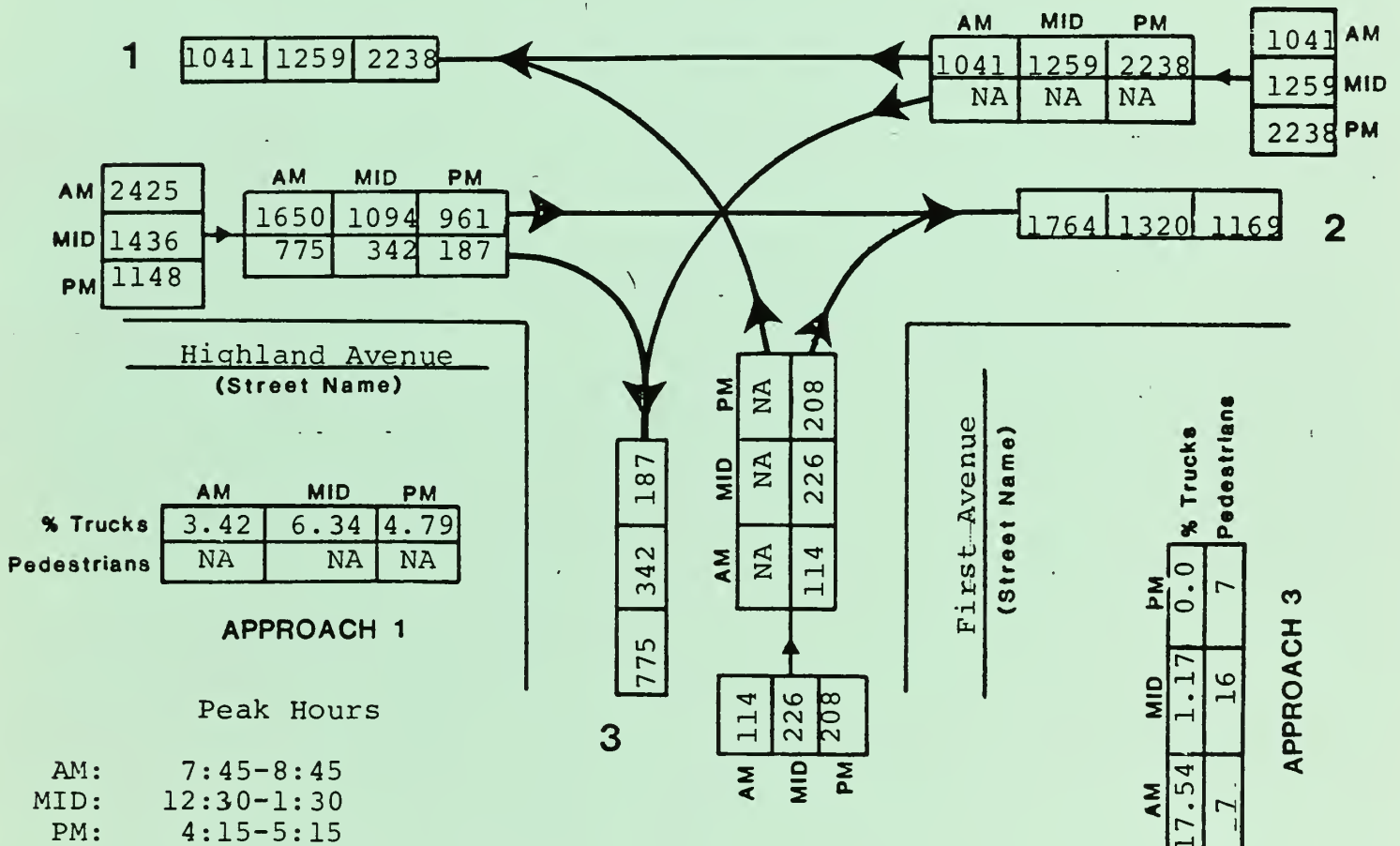
Date 9-18-84 Day of Week Tuesday Weather Fair 60°F Community Needham



APPROACH 2

AM	MID	PM	% Trucks	Pedestrians
NA	NA	NA		
7	22	5		

Highland Avenue
(Street Name)



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

A.M. Sept. '84

GENERAL CHARACTERISTICS

CONTROLS: STOP

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 4 LANES

MINOR STREET LANES

APPROACH: C: First Ave.

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

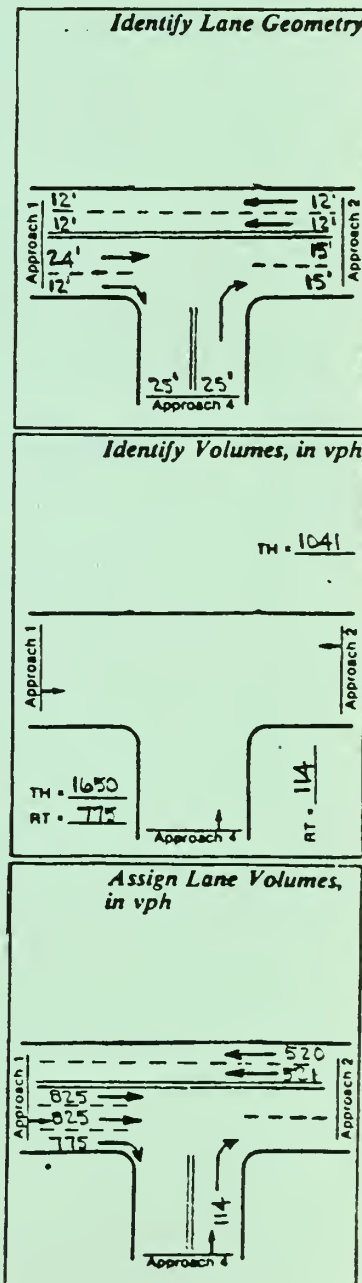
VOLUMES

APPROACH	A: Highland Av			B: Highland Av			C: First Ave.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	1650	775	0	0	0	0	0	114
PERCENT GRADE	0.00			0.00			0.00		
PASS CAR/HR	0			0			0	0	125

STEP 1 RIGHT TURNS FROM	C:First Ave.
CONFLICTING FLOWS	1213
CRITICAL GAP'S	6.0
CAPACITY	233
SHARED LANE	Y

STEP 2 LEFT TURNS FROM	B:Highland Ave.
CONFLICTING FLOWS	2425
CRITICAL GAP'S	5.5
CAPACITY	76
DEMAND	0
CAPACITY USED	0
IMPEDANCE FACTOR	1.00
AVAILABLE RESERVE	76
DELAY	Very long delay
LOS	E

STEP 3 LEFT TURNS FROM	C:First Ave.
CONFLICTING FLOWS	2038
CRITICAL GAP'S	5.0
CAPACITY	29
ADJUST FOR IMP	29
SHARED LANE THRU	Y
SHARED LANE RIGHT	Y
SHARED LN DEMAND	125
CAPACITY OF SHARED LN	233
AVAILABLE RESERVE	108
DELAY	Long traffic delay
LOS	D



MID Sept. '84

GENERAL CHARACTERISTICS

CONTROLS: STOP

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 4 LANES

MINOR STREET LANES

APPROACH: C: First Ave.

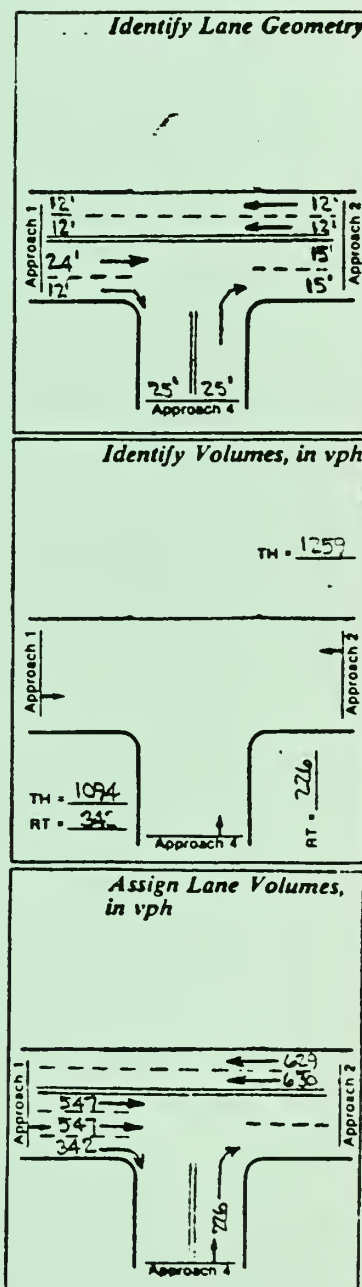
EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

VOLUMES

APPROACH	A: Highland Av			B: Highland Av			C: First Ave.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	1094	342	0	0	0	0	0	226
PERCENT GRADE	0.00			0.00			0.00		
PASS CAR/HR	0			0			0	0	249

STEP 1 RIGHT TURNS FROM	C:First Ave.
CONFLICTING FLOWS	718
CRITICAL GAPS	6.0
CAPACITY	422
SHARED LANE	Y
STEP 2 LEFT TURNS FROM	B:Highland Ave.
CONFLICTING FLOWS	1436
CRITICAL GAPS	5.5
CAPACITY	225
DEMAND	0
CAPACITY USED	0
IMPEDANCE FACTOR	1.00
AVAILABLE RESERVE	225
DELAY	Average traffic dela
LOS	C
STEP 3 LEFT TURNS FROM	C:First Ave.
CONFLICTING FLOWS	1265
CRITICAL GAPS	8.0
CAPACITY	99
ADJUST FOR IMP	99
SHARED LANE THRU	Y
SHARED LANE RIGHT	Y
SHARED LN DEMAND	249
CAPACITY OF SHARED LN	422
AVAILABLE RESERVE	174
DELAY	Long traffic delay
LOS	D



P.M. Sept. '84

GENERAL CHARACTERISTICS

CONTROLS: STOP

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 4 LANES

MINOR STREET LANES

APPROACH: C: First Ave.

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

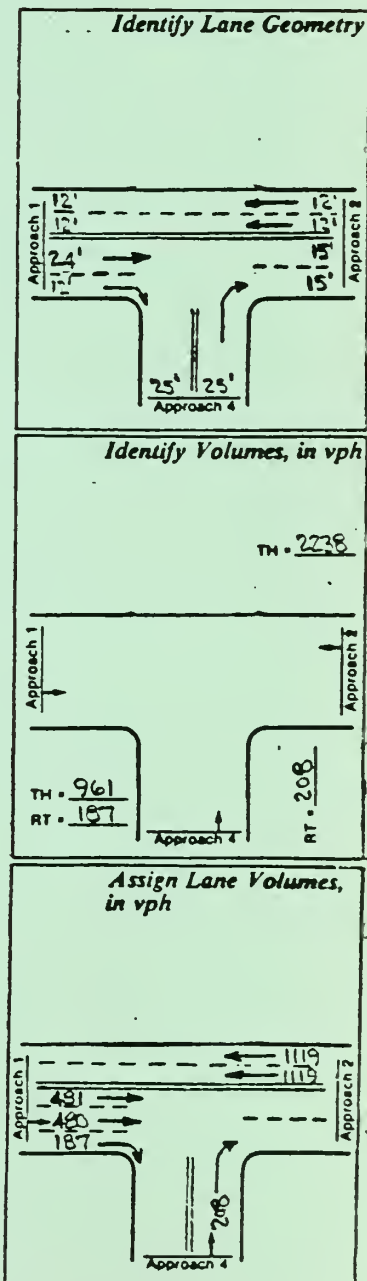
VOLUMES

APPROACH	A: Highland Av			B: Highland Av			C: First Ave.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	961	187	0	0	0	0	0	208
PERCENT GRADE	0.00			0.00			0.00		
PASS CAR/HR	0			0			0	0	229

STEP 1 RIGHT TURNS FROM C:First Ave.
 CONFLICTING FLOWS 574
 CRITICAL GAPS 6.0
 CAPACITY 502
 SHARED LANE Y

STEP 2 LEFT TURNS FROM B:Highland Ave
 CONFLICTING FLOWS 1148
 CRITICAL GAPS 5.5
 CAPACITY 309
 DEMAND 0
 CAPACITY USED 0
 IMPEDANCE FACTOR 1.00
 AVAILABLE RESERVE 309
 DELAY Short traffic delay
 LOS B

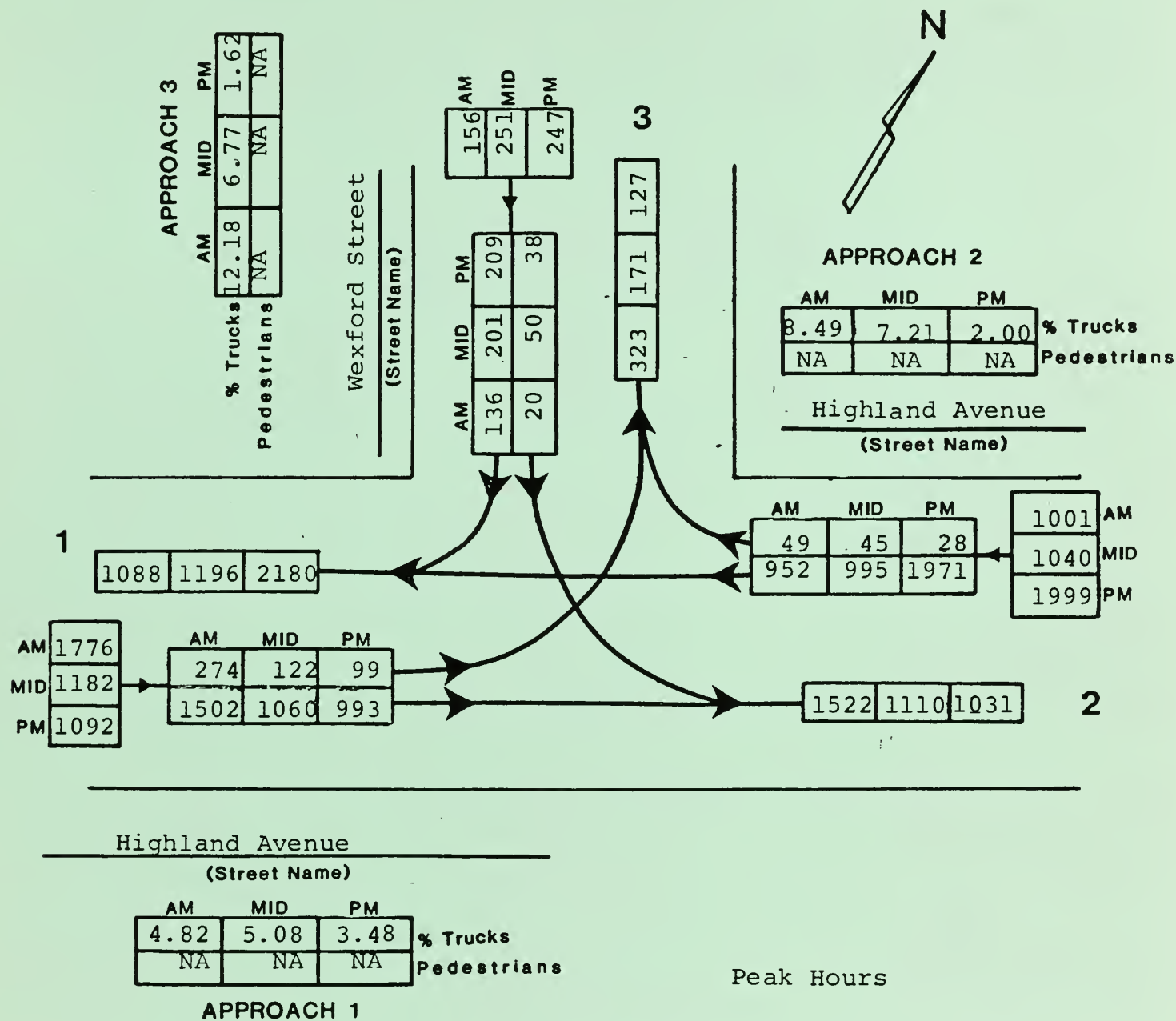
STEP 3 LEFT TURNS FROM C:First Ave.
 CONFLICTING FLOWS 1055
 CRITICAL GAPS 8.0
 CAPACITY 139
 ADJUST FOR IMP 139
 SHARED LANE THRU Y
 SHARED LANE RIGHT Y
 SHARED LN DEMAND 229
 CAPACITY OF SHARED LN 502
 AVAILABLE RESERVE 273
 DELAY Average traffic delay
 LOS C



SUMMARY OF VEHICLE MOVEMENTS

Intersection Highland Avenue @ Wexford Street

Date 9-18-84 Day of Week Tuesday Weather Fair 60°F Community Needham



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

A.M. with X Left/Right on Wexford St.

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 4 LANES

MINOR STREET LANES

APPROACH: C: Wexford St.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

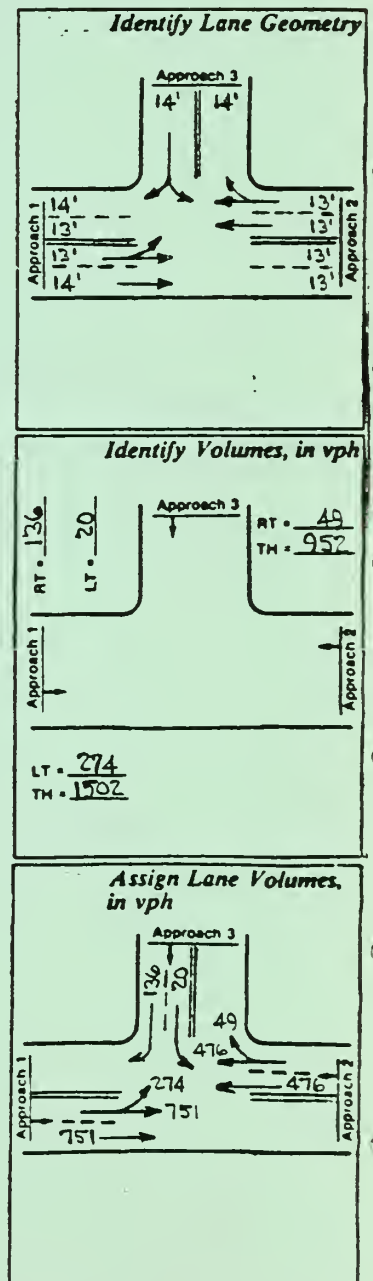
VOLUMES

APPROACH	A: Highland Av			B: Highland Av			C: Wexford St.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	952	49	274	1502	0	20	0	136
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00	
PASSENGER CARS		92.00			95.00			88.00	
PERCENT LT TRU		4.00			2.00			6.00	
PERCENT HV TRU		4.00			3.00			6.00	
PASS CAR/HR	0			285			22	0	148

STEP 1 RIGHT TURNS FROM	C: Wexford St.
CONFLICTING FLOWS	501
CRITICAL GAPS	5.0
CAPACITY	727
DEMAND	148
SHARED LANE	N
AVAILABLE RESERVE	579
DELAY	Little or no delay
LOS	A

STEP 2 LEFT TURNS FROM	B: Highland Ave.
CONFLICTING FLOWS	1001
CRITICAL GAPS	5.5
CAPACITY	363
DEMAND	285
CAPACITY USED	79
IMPEDANCE FACTOR	0.27
AVAILABLE RESERVE	78
DELAY	Very long delay
LOS	E

STEP 3 LEFT TURNS FROM	C: Wexford St.
CONFLICTING FLOWS	2753
CRITICAL GAPS	7.0
CAPACITY	18
ADJUST FOR IMP	5
SHARED LANE THRU	N
SHARED LANE RIGHT	N
DEMAND	22
AVAILABLE RESERVE	-17
DELAY	Failure
LOS	E*



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

MID with X Left/Right on Wexford St.

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 4 LANES

MINOR STREET LANES

APPROACH: C: Wexford St.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

VOLUMES

APPROACH	A: Highland Av			B: Highland Av			C: Wexford St.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	995	45	122	1060	0	50	0	201
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES	0.00			0.00			0.00		
PASSENGER CARS	93.00			95.00			92.00		
PERCENT LT TRU	3.00			2.00			4.00		
PERCENT HV TRU	4.00			3.00			4.00		
PASS CAR/HR	0			127			53	0	213

STEP 1 RIGHT TURNS FROM

C: Wexford St.

CONFLICTING FLOWS

520

CRITICAL GAPS

5.0

CAPACITY

713

DEMAND

213

SHARED LANE

N

AVAILABLE RESERVE

500

DELAY

Little or no delay

LOS

A

STEP 2 LEFT TURNS FROM

B: Highland Ave.

CONFLICTING FLOWS

1040

CRITICAL GAPS

5.5

CAPACITY

348

DEMAND

127

CAPACITY USED

37

IMPEDANCE FACTOR

0.71

AVAILABLE RESERVE

221

DELAY

Average traffic dela

LOS

C

STEP 3 LEFT TURNS FROM

C: Wexford St.

CONFLICTING FLOWS

2200

CRITICAL GAPS

7.0

CAPACITY

39

ADJUST FOR IMP

28

SHARED LANE THRU

N

SHARED LANE RIGHT

N

DEMAND

53

AVAILABLE RESERVE

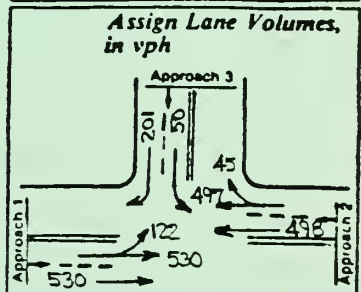
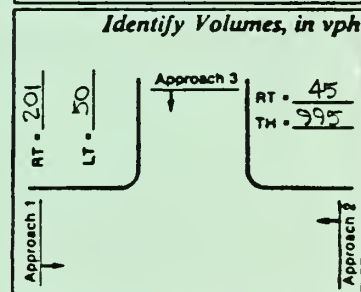
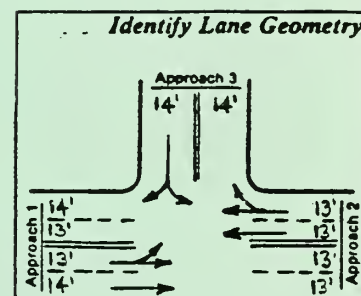
-25

DELAY

Failure

LOS

E*



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

P.M. with X Left/Right on Wexford St.

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 4 LANES

MINOR STREET LANES

APPROACH: C: Wexford St.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

VOLUMES

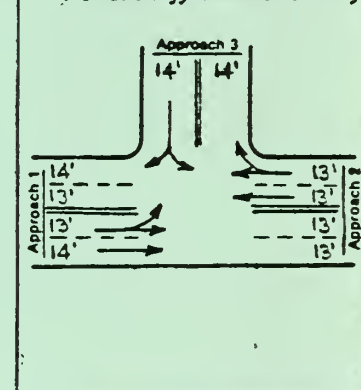
APPROACH	A: Highland Av			B: Highland Av			C: Wexford St.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	1971	28	99	993	0	38	0	209
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00	
PASSENGER CARS		98.00			97.00			98.00	
PERCENT LT TRU		1.00			1.00			1.00	
PERCENT HV TRU		1.00			2.00			1.00	
PASS CAR/HR	0			101			39	0	212

STEP 1 RIGHT TURNS FROM	C: Wexford St.
CONFLICTING FLOWS	1000
CRITICAL GAPS	5.0
CAPACITY	442
DEMAND	212
SHARED LANE	N
AVAILABLE RESERVE	230
DELAY	Average traffic dela
LOS	C

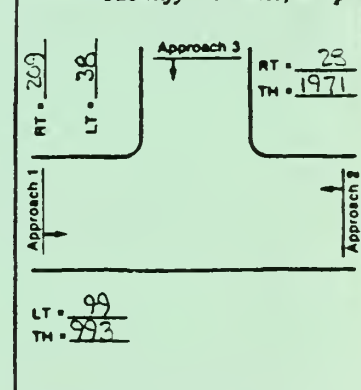
STEP 2 LEFT TURNS FROM	B: Highland Ave.
CONFLICTING FLOWS	1999
CRITICAL GAPS	5.5
CAPACITY	121
DEMAND	101
CAPACITY USED	84
IMPEDANCE FACTOR	0.21
AVAILABLE RESERVE	20
DELAY	Very long delay
LOS	E

STEP 3 LEFT TURNS FROM	C: Wexford St.
CONFLICTING FLOWS	3077
CRITICAL GAPS	7.0
CAPACITY	12
ADJUST FOR IMP	2
SHARED LANE THRU	N
SHARED LANE RIGHT	N
DEMAND	39
AVAILABLE RESERVE	-36
DELAY	Failure
LOS	E*

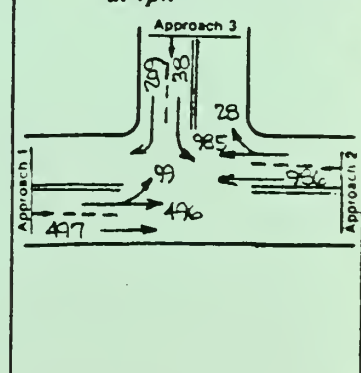
Identify Lane Geometry



Identify Volumes, in vph



Assign Lane Volumes, in vph



SUMMARY OF VEHICLE MOVEMENTS

Intersection Highland Avenue @ Second Avenue

Date 9/18/84 Day of Week Tuesday Weather Fair 65°F Community Needham

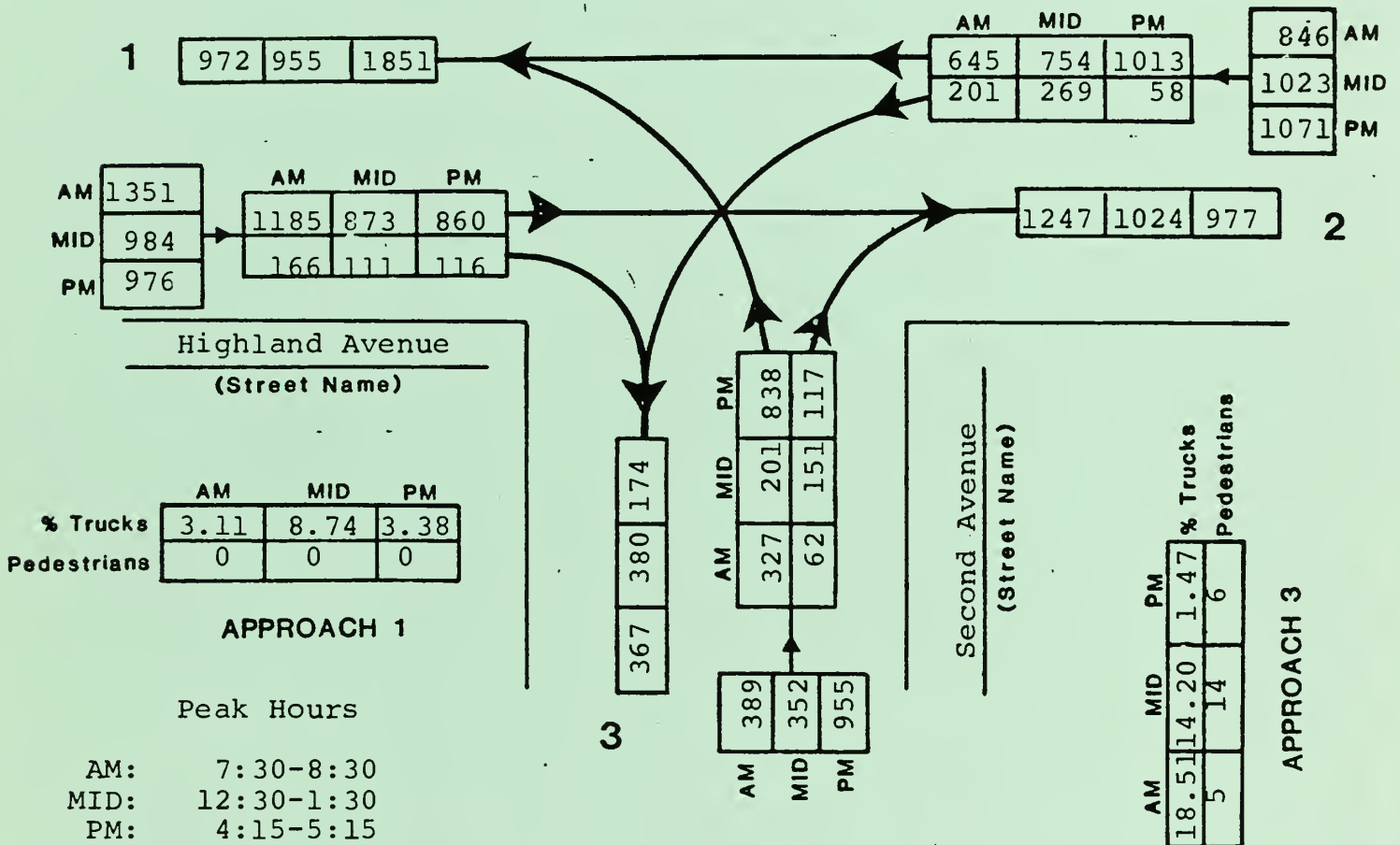


APPROACH 2

AM	MID	PM	
9.93	7.14	1.59	% Trucks
4	1	0	Pedestrians

Highland Avenue

(Street Name)



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

A.M. Sept. '84

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	None Present	Second Ave.
#THRU LANES	2	1	1	2
AVG WIDTH	12	12	10	12
#LT LANES	0	1	0	0
AVG WIDTH	0	12	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	0	201	0	327
THRU VOL	1185	645	0	0
RT VOL	166	0	0	62
PED VOL	0	4	0	5
TRUCK %	3.1	9.9	0.0	18.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE (secs)	68	68	68	68
CHANGE INT	53	53	53	53
LT CAP ON CI	106	106	106	106
G/C	.77	.77	.22	.22
OP VOL	645	1351	62	0
LT CAP ON GR	279	0	202	264
LT TOT CAP	385	106	308	370
LT VOL	0	201	0	327
PASS CHK	t	f	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.91	0.94	1.00	0.89
LT VOL	0	235	0	435
THRU VOL	1343	754	0	0
RT VOL	188	0	0	83

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	645	1351	62	0
PCE LTU	4.00	6.00	1.00	1.00
PCE LTP	1.20	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B1	1410	247
A2	754	754
A1B2	1531	1531
A2B1	392	341
A4B3	518	605

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B1	1410	247
A2	754	754

A2B1	392	341
A4B3	272	318

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

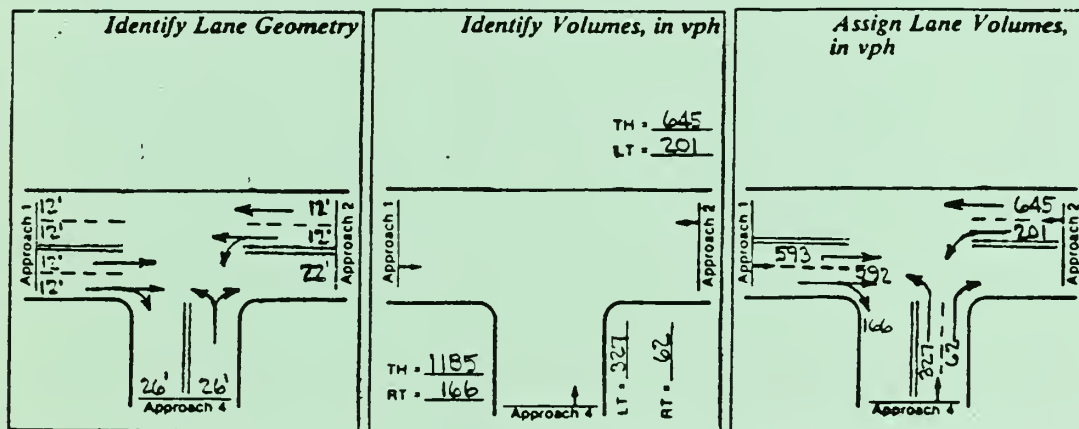
1410	1-one phase only
1050	2-two phase, one left protected, no overlap
1050	3-two phases, one left protected, overlap
1558	8-two phases, directional split

POSSIBLE PHASES APPROACHES 3 & 4

272	1-one phase only
318	8-two phases, directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
EXISTING 2	1	0.77	1322	1720	C
CONDITION 3	1	0.77	1322	1720	C
2	8	0.83	1368	1650	D
3	8	0.83	1368	1650	D
1*	1	0.93	1682	1800	E
1*	8	1.00	1728	1720	F
8	1	1.06	1830	1720	F
8	8	1.14	1875	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above



MID Sept. '84

STEP ONE OUTPUT

NAME	1 Highland Ave.	2 Highland Ave.	3 None Present	4 Second Ave.
#THRU LANES	2	1	1	2
AVG WIDTH	12	12	10	12
#LT LANES	0	1	0	0
AVG WIDTH	0	12	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	0	269	0	201
THRU VOL	873	754	0	0
RT VOL	111	0	0	151
PED VOL	0	1	0	14
TRUCK %	8.7	7.1	0.0	14.2
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE (secs)	68	68	68	68
CHANGE INT	53	53	53	53
LT CAP ON CI	106	106	106	106
G/C	.81	.81	.18	.18
OP VOL	754	984	151	0
LT CAP ON GR	218	0	65	216
LT TOT CAP	324	106	171	322
LT VOL	0	269	0	201
PASS CHK	t	f	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.94	0.91	1.00	0.93
LT VOL	0	317	0	247
THRU VOL	1010	887	0	0
RT VOL	128	0	0	185

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	754	984	151	0
PCE LTU	4.00	4.00	1.00	1.00
PCE LTP	1.20	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B1	1266	332
A2	887	887
A1B2	1138	1138
A2B1	746	649
A4B3	432	482

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B1	1266	332
A2	887	887

A2B1
A4B3

746
227

647
253

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

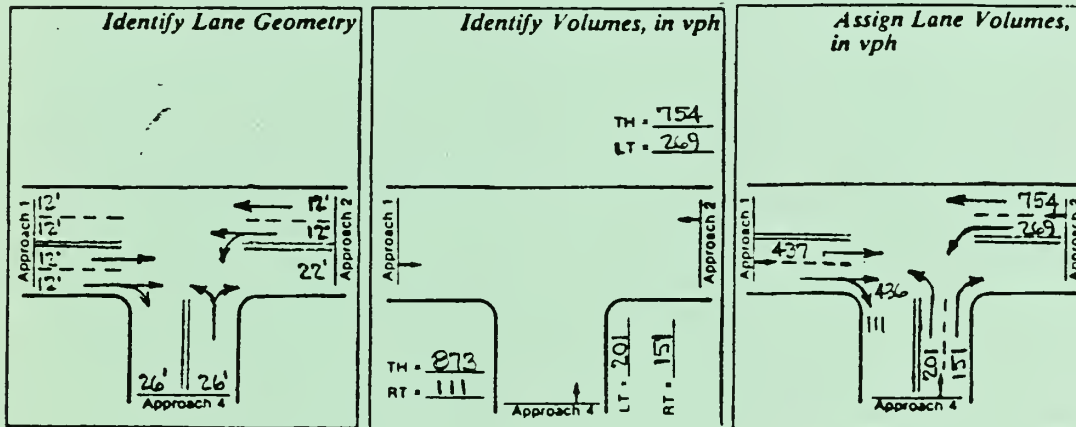
1266 1-one phase only
1220 2-two phase, one left protected, no overlap
930 3-two phases, one left protected, overlap
1485 8-two phases, directional split

POSSIBLE PHASES APPROACHES 3 & 4

227 1-one phase only
253 8-two phases, directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
Existing condition → 3	1	0.67	1157	1720	C
3	8	0.72	1183	1650	C
1*	1	0.83	1493	1800	D
2	1	0.84	1447	1720	D
1*	8	0.88	1519	1720	D
2	8	0.89	1473	1650	E
8	1	1.00	1712	1720	E
8	8	1.05	1738	1650	F

This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

P.M. Sept. '84

Exclusive left included
for 2nd one left protect
overlap on Approach 2

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	None Present	Second Ave.
#THRU LANES	2	1	1	2
AVG WIDTH	12	12	10	12
#LT LANES	0	1	0	0
AVG WIDTH	0	12	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	0	58	0	838
THRU VOL	860	1013	0	0
RT VOL	116	0	0	117
PED VOL	0	0	0	6
TRUCK %	3.4	1.6	0.0	1.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	68	68	68	68
CHANGE INT	53	53	53	53
LT CAP ON CI	106	106	106	106
G/C	.67	.67	.32	.32
OP VOL	1013	976	117	0
LT CAP ON GR	0	0	267	384
LT TOT CAP	106	106	373	490
LT VOL	0	58	0	838
PASS CHK	t	t	t	f

STEP SIX OUTPUT

	1	2	3	4
PHF	0.91	0.89	1.00	0.86
LT VOL	0	66	0	989
THRU VOL	977	1156	0	0
RT VOL	132	0	0	138

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	1013	976	117	0
PCE LTU	6.00	4.00	1.00	1.00
PCE LTP	1.20	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

UNPROTECT LT

PROTECT LT

B1	265	70
A2	1156	1156
A1B2	1109	1109
A4B3	1127	1325

STEP EIGHT AND NINE A OUTPUT

UNPROTECT LT

PROTECT LT

B1	265	70
A2	1156	1156
A1B2	1109	1109
A4B3	1127	1325

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

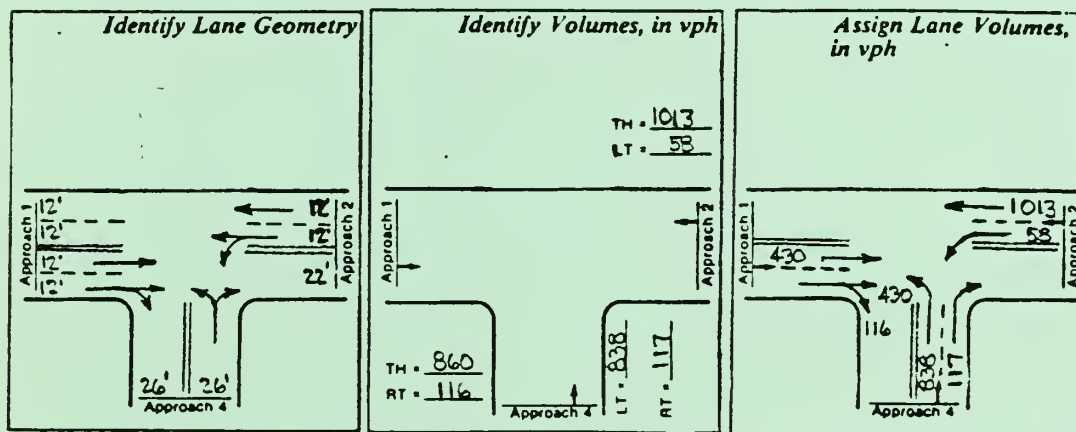
1156 1-one phase only
 1226 2-two phase, one left protected, no overlap
 1156 3-two phases, one left protected, overlap
 1739 8-two phases, directional split

POSSIBLE PHASES APPROACHES 3 & 4

592 1-one phase only
 696 8-two phases, directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
existing condition → 1	1*	0.97	1748	1800	E
→ 3	1*	1.02	1748	1720	F
2	1*	1.06	1818	1720	F
1	8	1.08	1852	1720	F
3	8	1.12	1852	1650	F
2	8	1.16	1922	1650	F
8	1*	1.35	2330	1720	F
8	8	1.48	2434	1650	F

* This phasing may be inappropriate due to left turn restrictions
 see STEP FOUR OUTPUT above



AM ADD XRIGHT TO SECOND AVE ADD ADDITIONAL THROUGH (XLEFT) TO HIGHLAND AVE

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	None	Second Ave.
#THRU LANES	2	2	1	2
AVG WIDTH	12	11	10	11
#LT LANES	0	1	0	0
AVG WIDTH	0	10	0	0
#RT LANES	0	0	0	1
AVG WIDTH	0	0	0	10

STEP TWO OUTPUT

	1	2	3	4
LT VOL	0	201	0	327
THRU VOL	1185	645	0	0
RT VOL	166	0	0	62
PED VOL	0	4	0	5
TRUCK %	3.1	0.9	0.0	18.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	68	68	68	68
CHANGE INT	53	53	53	53
LT CAP ON CI	106	106	106	106
G/C	.80	.80	.19	.19
OP-VOL	645	1351	62	0
LT CAP ON GR	315	0	166	228
LT TOT CAP	421	106	272	334
LT VOL	0	201	0	327
PASS CHK	t	f	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.91	0.94	0.00	0.89
LT VOL	0	216	0	435
THRU VOL	1343	692	0	0
RT VOL	188	0	0	83

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	645	1351	62	0
PCE LTU	4.00	6.00	1.00	1.00
PCE LTP	1.20	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B1	1295	227
A2	692	692
A1B2	1531	1531
A4B3	435	522

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B1	1295	227
A2	363	363

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

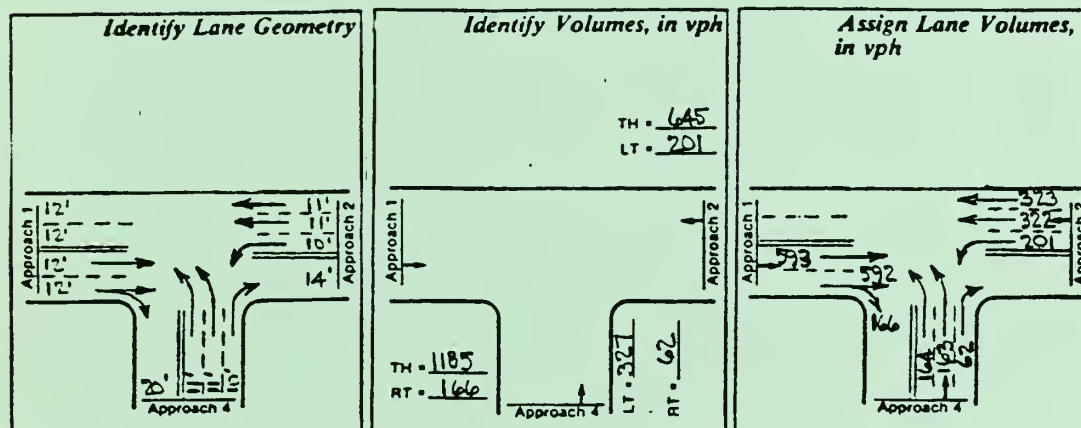
1295	1-one phase only
1030	2-two phase,one left protected,no overlap
1030	3-two phases,one left protected,overlap
1167	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

229	1-one phase only
274	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
3	1	0.73	1259	1720	C
2	1	0.73	1259	1720	C
2	8	0.79	1304	1650	D
3	8	0.79	1304	1650	D
8	1	0.81	1396	1720	D
1*	1	0.85	1523	1800	D
8	8	0.87	1441	1650	D
1*	8	0.91	1569	1720	E

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

MID ADD XRIGHT TO SECOND AVE ADD ADDITIONAL THROUGH (XLEFT) TO HIGHLAND AVE

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	None	Second Ave.
#THRU LANES	2	2	1	2
AVG WIDTH	12	11	10	11
#LT LANES	0	1	0	0
AVG WIDTH	0	10	0	0
#RT LANES	0	0	0	1
AVG WIDTH	0	0	0	10

STEP TWO OUTPUT

	1	2	3	4
LT VOL	0	269	0	201
THRU VOL	633	754	0	0
RT VOL	111	0	0	151
PED VOL	0	1	0	14
TRUCK %	8.7	7.1	0.0	14.2
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

CYCLE (secs)	68	68	68	68
CHANGE INT	53	53	53	53
LT CAP ON CI	106	106	106	106
G/C	.71	.71	.28	.28
OP VOL	754	744	151	0
LT CAP ON GR	98	108	185	336
LT TOT CAP	204	214	291	442
LT VOL	0	269	0	201
PASS CHK	t	f	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.94	0.91	0.00	0.93
LT VOL	0	317	0	247
THRU VOL	732	887	0	0
RT VOL	128	0	0	185

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	754	744	151	0
PCE LTU	4.00	4.00	1.00	1.00
PCE LTP	1.20	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B1	1266	332
A2	887	887
A1B2	860	860
A4B3	247	296

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B1	1266	332

A4B3**

185

185

** The critical lane volume occurs in the exclusive right turn lane(s)

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

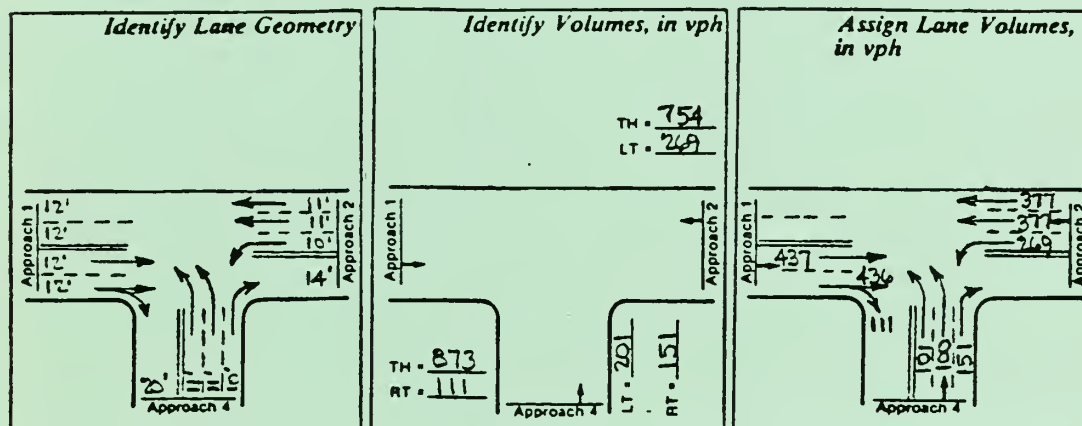
1266 1-one phase only
 798 2-two phase, one left protected, no overlap
 784 3-two phases, one left protected, overlap
 918 8-two phases, directional split

POSSIBLE PHASES APPROACHES 3 & 4

185 1-one phase only
 185 8-two phases, directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
3	1	0.56	970	1720	B
2	1	0.57	984	1720	B
3	8	0.59	970	1650	B
2	8	0.60	984	1650	B
8	1	0.64	1103	1720	B
8	8	0.67	1103	1650	B
1*	1	0.81	1452	1800	D
1*	8	0.84	1452	1720	D

* This phasing may be inappropriate due to left turn restrictions
 see STEP FOUR OUTPUT above



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

PM ADD XRIGHT TO SECOND AVE ADD ADDITIONAL THROUGH (XLEFT) TO HIGHLAND AVE

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	None	Second Ave.
#THRU LANES	2	2	1	2
AVG WIDTH	12	11	10	11
#LT LANES	0	1	0	0
AVG WIDTH	0	10	0	0
#RT LANES	0	0	0	1
AVG WIDTH	0	0	0	10

STEP TWO OUTPUT

	1	2	3	4
LT VOL	0	58	0	838
THRU VOL	860	1013	0	0
RT VOL	116	0	0	117
PED VOL	0	0	0	6
TRUCK %	3.4	1.6	0.0	1.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

CYCLE(secs)	68	68	68	68
CHANGE INT	53	53	53	53
LT CAP ON CI	106	106	106	106
G/C	.54	.54	.45	.45
OP VOL	1013	976	117	0
LT CAP ON GR	0	0	423	540
LT TOT CAP	106	106	529	646
LT VOL	0	58	0	838
PASS CHK	t	t	t	f

STEP SIX OUTPUT

	1	2	3	4
PHF	0.91	0.89	0.00	0.86
LT VOL	0	66	0	989
THRU VOL	977	1156	0	0
RT VOL	132	0	0	138

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	1013	976	117	0
PCE LTU	6.00	4.00	1.00	1.00
PCE LTP	1.20	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B1	265	70
A2	1156	1156
A1B2	1109	1109
A4B3	989	1187

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B1	265	70

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

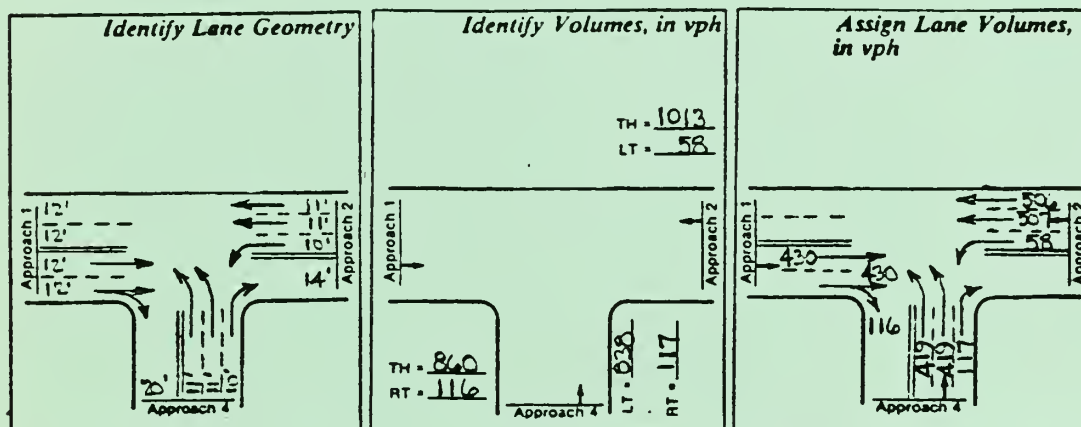
607	1-one phase only
677	2-two phase, one left protected, no overlap
652	3-two phases, one left protected, overlap
1189	8-two phases, directional split

POSSIBLE PHASES APPROACHES 3 & 4

519	1-one phase only
623	8-two phases, directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1	1*	0.63	1126	1800	B
3	1*	0.68	1171	1720	C
2	1*	0.70	1196	1720	C
1	8	0.72	1230	1720	C
3	8	0.77	1275	1650	C
2	8	0.79	1300	1650	D
8	1*	0.99	1709	1720	E
8	8	1.10	1812	1650	F

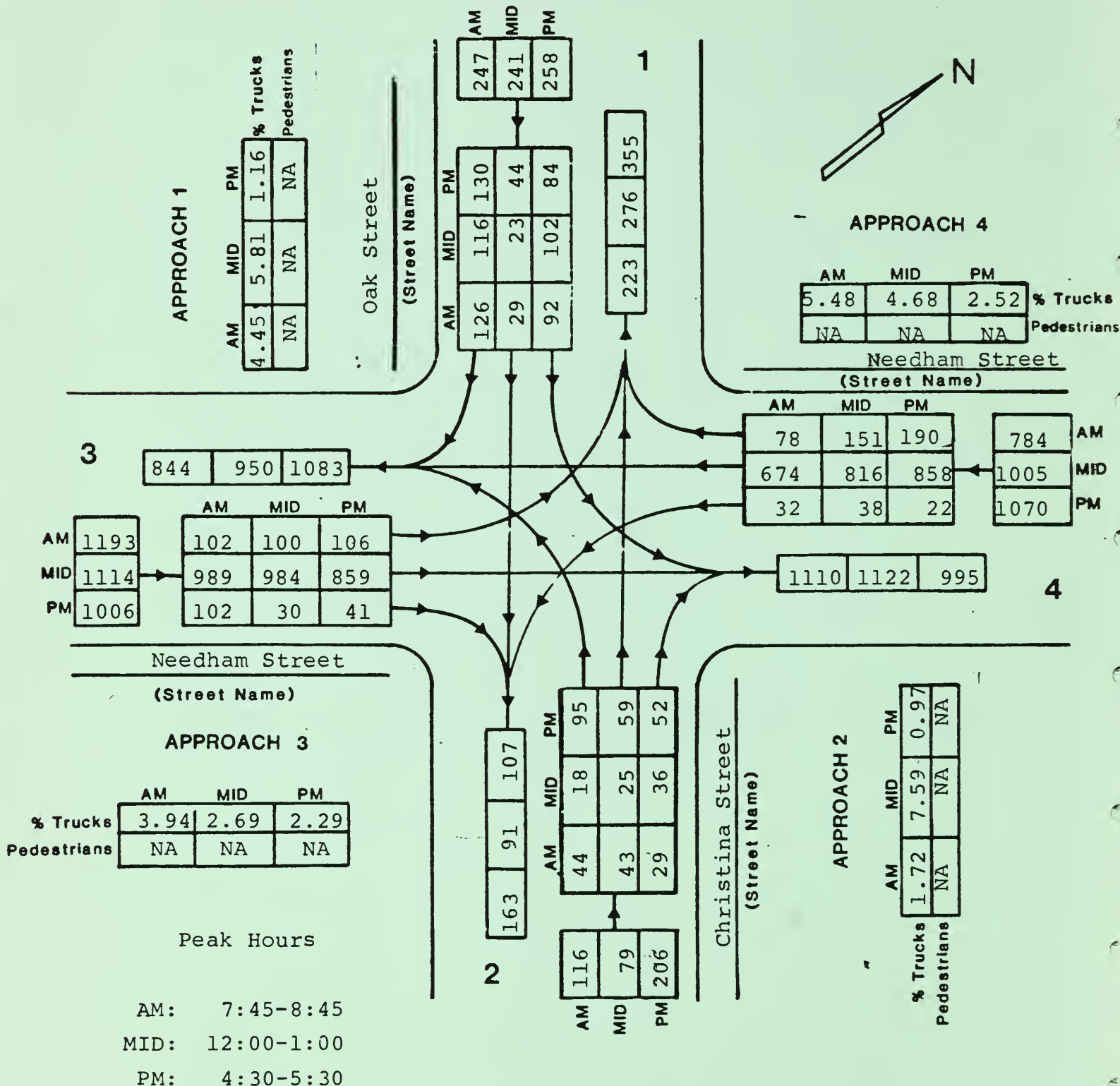
* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above



SUMMARY OF VEHICLE MOVEMENTS

Intersection Needham Street @ Oak Street & Christina Street

Date 9/18/84 Day of Week Tuesday Weather Fair 60°F Community Newton



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES

A.M. Sept. '84

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Christina St.

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: Oak St.

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

VOLUMES

APPROACH	A: Needham St.			B: Needham St.			C: Christina S			D: Oak St.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	102	989	102	32	674	78	44	43	29	92	29	126
PERCENT GRADE	0.00			0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00			0.00	
PASSENGER CARS		96.00			95.00			98.00			96.00	
PERCENT LT TRU		2.00			2.00			1.00			2.00	
PERCENT HV TRU		2.00			3.00			1.00			2.00	
PASS CAR/HR	105			33			45	44	29	95	30	130

STEP 1 RIGHT TURNS FROM

CONFLICTING FLOWS

CRITICAL GAPS

CAPACITY

DEMAND

CAPACITY USED

IMPEDANCE FACTOR

SHARED LANE

C: Christina St.

1040

5.0

424

29

7

0.96

Y

D: Oak St.

713

5.0

588

130

22

0.84

Y

STEP 2 LEFT TURNS FROM

CONFLICTING FLOWS

CRITICAL GAPS

CAPACITY

DEMAND

CAPACITY USED

IMPEDANCE FACTOR

AVAILABLE RESERVE

DELAY

LOS

B: Needham St.

1091

5.0

403

33

8

0.95

370

Short traffic delay Little or no delay

B

A: Needham St.

752

5.0

566

105

19

0.87

461

A

STEP 3 THRU MOVES FROM
 CONFLICTING FLOWS
 CRITICAL GAPS
 CAPACITY
 ADJUST FOR IMP
 DEMAND
 CAPACITY USED
 IMPEDANCE FACTOR
 SHARED LANE LEFT
 SHARED LANE RIGHT

C:Christina St.
 1926
 6.0
 99
 82
 44
 53
 0.54
 Y
 Y

D:Oak St.
 1938
 6.0
 98
 81
 30
 37
 0.71
 Y
 Y

STEP 4 LEFT TURNS FROM
 CONFLICTING FLOWS
 CRITICAL GAPS
 CAPACITY
 ADJUST FOR IMP
 SHARED LANE THRU
 SHARED LANE RIGHT
 SHARED LN DEMAND
 CAPACITY OF SHARED LN
 AVAILABLE RESERVE
 DELAY
 LOS

C:Christina St.
 2081
 6.5
 62
 30
 Y
 Y
 118
 57
 -61

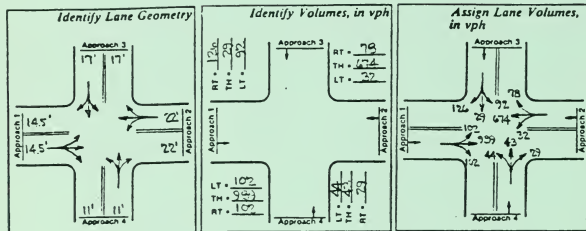
D:Oak St.
 2010
 6.5
 68
 29
 Y
 Y
 254
 67
 -188

Failure

E*

Failure

E*



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES

MID Sept. '84

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Christina St.

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: Oak St.

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

VOLUMES

APPROACH	A: Needham St.			B: Needham St.			C: Christina St.			D: Oak St.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	100	984	30	38	816	151	18	25	36	102	23	116
PERCENT GRADE	0.00			0.00			0.00			0.00		
PERCENT CYCLES	0.00			0.00			0.00			0.00		
PASSENGER CARS	97.00			95.00			92.00			94.00		
PERCENT LT TRU	1.00			2.00			4.00			3.00		
PERCENT HV TRU	2.00			3.00			4.00			3.00		
PASS CAR/HR	103			40			19	26	38	107	24	121

STEP 1 RIGHT TURNS FROM	C: Christina St.
CONFLICTING FLOWS	999
CRITICAL GAPS	5.0
CAPACITY	442
DEMAND	38
CAPACITY USED	9
IMPEDANCE FACTOR	0.95
SHARED LANE	Y

D: Oak St.

892

5.0

492

121

25

0.82

Y

STEP 2 LEFT TURNS FROM	B: Needham St.	A: Needham St.
------------------------	----------------	----------------

CONFLICTING FLOWS	1014	967
CRITICAL GAPS	5.0	5.0
CAPACITY	435	456
DEMAND	40	103
CAPACITY USED	9	22
IMPEDANCE FACTOR	0.95	0.84
AVAILABLE RESERVE	396	354
DELAY	Short traffic delay	Short traffic delay
LOS	B	B

STEP 3 THRU MOVES FROM
CONFLICTING FLOWS
CRITICAL GAPS
CAPACITY
ADJUST FOR IMP
DEMAND
CAPACITY USED
IMPEDANCE FACTOR
SHARED LANE LEFT
SHARED LANE RIGHT

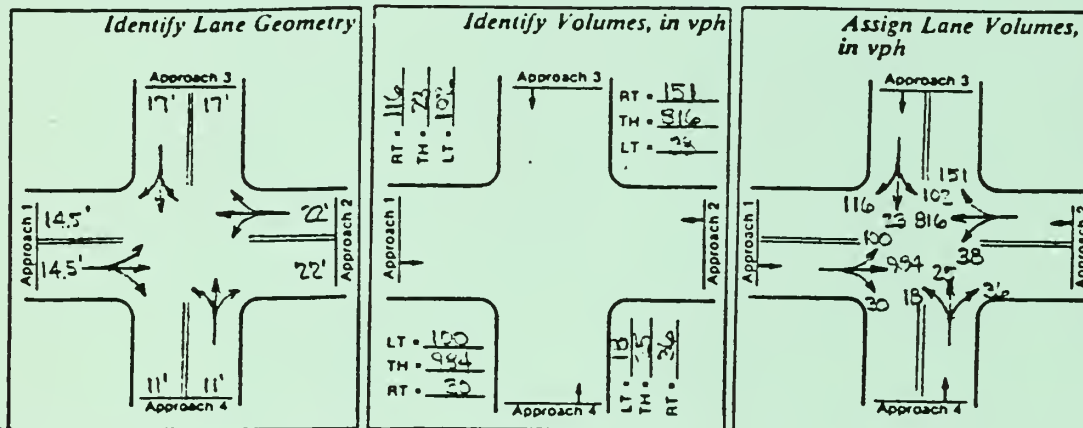
C:Christina St.
2104
6.0
80
63
26
42
0.66
Y
Y

D:Oak St.
2044
6.0
86
68
24
35
0.72
Y
Y

STEP 4 LEFT TURNS FROM
CONFLICTING FLOWS
CRITICAL GAPS
CAPACITY
ADJUST FOR IMP
SHARED LANE THRU
SHARED LANE RIGHT
SHARED LN DEMAND
CAPACITY OF SHARED LN
AVAILABLE RESERVE
DELAY
LOS

C:Christina St.
2243
6.5
50
23
Y
Y
84
64
-20
Failure
E*

D:Oak St.
2105
6.5
60
30
Y
Y
252
60
-192
Failure
E*



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES

P.M. Sept. '84

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Christina St.

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: Oak St.

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

VOLUMES

APPROACH	A: Needham St.			B: Needham St.			C: Christina St.			D: Oak St.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	106	859	41	22	858	190	95	59	52	84	44	130
PERCENT GRADE	0.00			0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00			0.00	
PASSENGER CARS		98.00			97.00			99.00			99.00	
PERCENT LT TRU		1.00			1.00			0.00			0.00	
PERCENT HV TRU		1.00			2.00			1.00			1.00	
PASS CAR/HR	108			23			96	60	53	85	44	131

STEP 1 RIGHT TURNS FROM

C: Christina St.

D: Oak St.

CONFLICTING FLOWS

880

953

CRITICAL GAPS

5.0

5.0

CAPACITY

498

463

DEMAND

53

131

CAPACITY USED

11

28

IMPEDANCE FACTOR

0.94

0.79

SHARED LANE

Y

Y

STEP 2 LEFT TURNS FROM

B: Needham St.

A: Needham St.

CONFLICTING FLOWS

900

1048

CRITICAL GAPS

5.0

5.0

CAPACITY

488

421

DEMAND

23

108

CAPACITY USED

5

26

IMPEDANCE FACTOR

0.98

0.81

AVAILABLE RESERVE

465

313

DELAY

Little or no delay

Short traffic delay

LOS

A

B

STEP 3 THRU MOVES FROM
CONFLICTING FLOWS
CRITICAL GAPS
CAPACITY
ADJUST FOR IMP
DEMAND
CAPACITY USED
IMPEDANCE FACTOR
SHARED LANE LEFT
SHARED LANE RIGHT

C:Christina St.
2056
6.0
85
67
60
89
0.15
Y
Y

D:Oak St.
1981
6.0
93
73
44
60
0.47
Y
Y

STEP 4 LEFT TURNS FROM
CONFLICTING FLOWS
CRITICAL GAPS
CAPACITY
ADJUST FOR IMP
SHARED LANE THRU
SHARED LANE RIGHT
SHARED LN DEMAND
CAPACITY OF SHARED LN
AVAILABLE RESERVE
DELAY
LOS

C:Christina St.
2230
6.5
51
15
Y
Y
208
28
-180

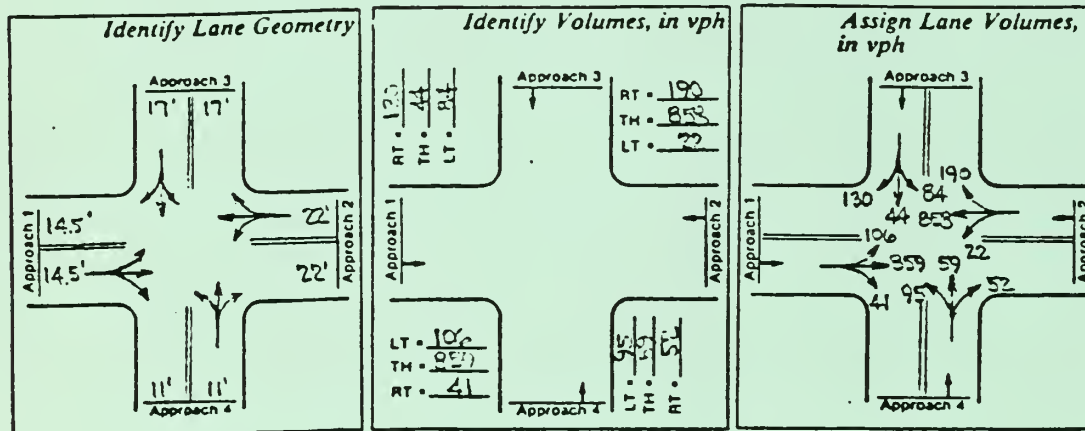
D:Oak St.
2092
6.5
61
7
Y
Y
261
20
-241

Failure

E*

Failure

E*



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

AM INSTALL SIGNALS WITH EXCLUSIVE LEFT LANES ON NEEDHAM ST. REDUCE RIGHT TURN FROM OAK ST BY 15%

STEP ONE OUTPUT

	1	2	3	4
NAME	Needham St.	Needham St.	Oak St.	Christina St.
#THRU LANES	1	1	1	1
AVG WIDTH	12	12	12	12
#LT LANES	1	1	0	0
AVG WIDTH	12	12	0	0
#RT LANES	0	0	1	0
AVG WIDTH	0	0	10	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	102	32	92	44
THRU VOL	989	674	29	43
RT VOL	102	78	107	29
PED VOL	0	0	0	0
TRUCK %	3.9	5.5	4.5	1.7
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	60	60	60	60
CHANGE INT	60	60	60	60
LT CAP ON CI	120	120	120	120
G/C	.90	.90	%9.90	%9.90
OP VOL	752	1091	72	136
LT CAP ON GR	328	0	%11808	%11744
LT TOT CAP	448	120	%11928	%11864
LT VOL	102	32	92	44
PASS CHK	t	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.90	0.88	0.88	0.88
LT VOL	118	38	109	51
THRU VOL	1142	808	34	50
RT VOL	118	94	127	34

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	752	1091	72	136
PCE LTU	4.00	6.00	1.00	1.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

UNPROTECT LT PROTECT LT

B2	471	124
A1	1259	1259
B1	230	40
A2	902	902
A3B4	144	166
A4B3	134	144

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B2	471	124
A1	1259	1259
B1	230	40
A2	902	902
A3B4	144	166
A4B3	134	144

STEP TEN OUTPUT

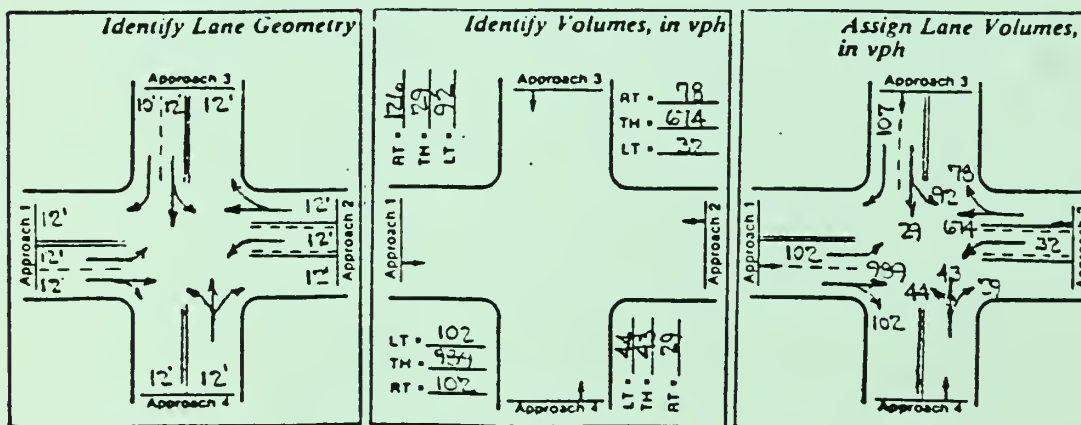
POSSIBLE PHASES APPROACHES 1 & 2

1259	1-one phase only
1383	2-two phase,one left protected,no overlap
1259	3-two phases,one left protected,overlap
1383	4-two phases,both lefts protected,no overlap
1300	5-three phases,both lefts protected,overlap
1423	6-three phases,lead/lag,no overlap
1490	7-three phases,lead/lag,overlap
2161	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

144	1-one phase only
310	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1	1	0.78	1403	1800	C
3	1	0.82	1403	1720	D
5	1	0.87	1443	1650	D
4	1	0.89	1527	1720	D
2	1	0.89	1527	1720	D
1	8	0.91	1569	1720	E
6	1	0.95	1567	1650	E
3	8	0.95	1569	1650	E
5	8	0.98	1610	1650	E
7	1	0.99	1633	1650	E
2	8	1.03	1693	1650	F
4	8	1.03	1693	1650	F
6	8	1.05	1733	1650	F
7	8	1.09	1799	1650	F
8	1	1.34	2305	1720	F
8	8	1.50	2471	1650	F



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

MID INSTALL SIGNAL WITH EXCLUSIVE LEFT LANES ON NEEDHAM ST REDUCE RIGHT TURNS
FROM OAK ST BY 15%

STEP ONE OUTPUT

	1	2	3	4
NAME	Needham St.	Needham St.	Oak St.	Christina St.
#THRU LANES	1	1	1	1
AVG WIDTH	12	12	12	12
#LT LANES	1	1	0	0
AVG WIDTH	12	12	0	0
#RT LANES	0	0	1	0
AVG WIDTH	0	0	10	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	100	38	102	18
THRU VOL	984	816	23	25
RT VOL	30	151	99	36
PED VOL	0	0	0	0
TRUCK %	2.7	4.7	5.8	7.6
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE (secs)	60	60	60	60
CHANGE INT	60	60	60	60
LT CAP ON CI	120	120	120	120
G/C	.89	.89	.10	.10
OP VOL	967	1014	61	122
LT CAP ON GR	101	54	59	0
LT TOT CAP	221	174	179	120
LT VOL	100	38	102	18
PASS CHK	t	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.90	0.89	0.89	0.60
LT VOL	114	45	121	32
THRU VOL	1123	960	27	45
RT VOL	34	178	118	65

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	967	1014	61	122
PCE LTU	4.00	6.00	1.00	1.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B2	456	120
A1	1157	1157
B1	268	47
A2	1138	1138
A3B4	149	173
A4B3	142	148

STEP EIGHT AND NINE A OUTPUT

	UNPROTECTED LT	PROTECTED LT
B2	456	120
A1	1157	1157
B1	268	47
A2	1138	1138
A3B4	149	173
A4B3	142	148

STEP TEN OUTPUT

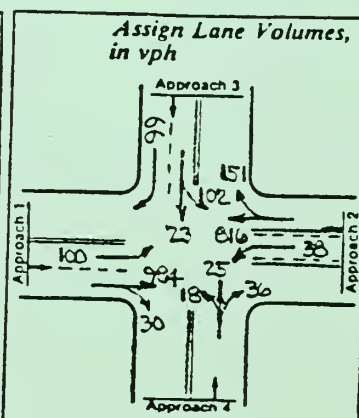
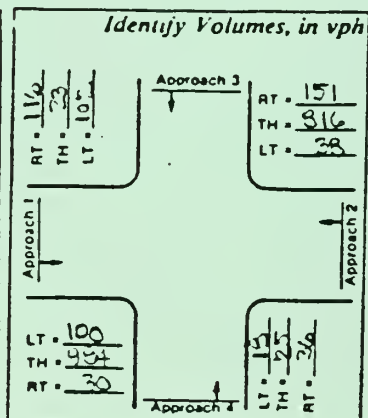
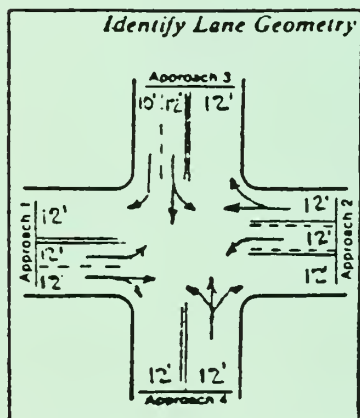
POSSIBLE PHASES APPROACHES 1 & 2

1157	1-one phase only
1277	2-two phase,one left protected,no overlap
1257	3-two phases,one left protected,overlap
1277	4-two phases,both lefts protected,no overlap
1257	5-three phases,both lefts protected,overlap
1324	6-three phases,lead/lag,no overlap
1594	7-three phases,lead/lag,overlap
2295	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

149	1-one phase only
321	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1	1	0.73	1306	1800	C
3	1	0.82	1406	1720	D
4	1	0.83	1425	1720	D
2	1	0.83	1425	1720	D
5	1	0.85	1406	1650	D
1	8	0.86	1478	1720	D
6	1	0.89	1472	1650	E
5	8	0.96	1578	1650	E
3	8	0.96	1578	1650	E
4	8	0.97	1598	1650	E
2	8	0.97	1598	1650	E
6	8	1.00	1645	1650	E
7	1	1.06	1743	1650	F
7	8	1.16	1915	1650	F
8	1	1.42	2443	1720	F
8	8	1.59	2616	1650	F



STEP ONE OUTPUT

	1	2	3	4
NAME	Needham St.	Needham St.	Oak St.	Christina St.
#THRU LANES	1	1	1	1
AVG WIDTH	12	12	12	12
#LT LANES	1	1	0	0
AVG WIDTH	12	12	0	0
#RT LANES	0	0	1	0
AVG WIDTH	0	0	10	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	106	22	84	95
THRU VOL	859	858	44	59
RT VOL	41	190	110	52
PED VOL	0	0	0	0
TRUCK %	2.3	2.5	1.2	1.0
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	60	60	60	60
CHANGE INT	60	60	60	60
LT CAP ON CI	120	120	120	120
G/C	.83	.83	.16	.16
OP VOL	1048	900	111	154
LT CAP ON GR	0	96	81	38
LT TOT CAP	120	216	201	158
LT VOL	106	22	84	95
PASS CHK	t	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.87	0.90	0.84	0.72
LT VOL	125	25	101	133
THRU VOL	1010	977	53	83
RT VOL	48	216	133	73

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	1048	900	111	154
PCE LTU	6.00	4.00	1.00	1.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B2	748	131
A1	1058	1058
B1	100	26
A2	1194	1194
A3B4	154	174
A4B3	289	316

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B2	748	131
A1	1058	1058
B1	100	26
A2	1194	1194
A3B4	154	174
A4B3	289	316

STEP TEN OUTPUT

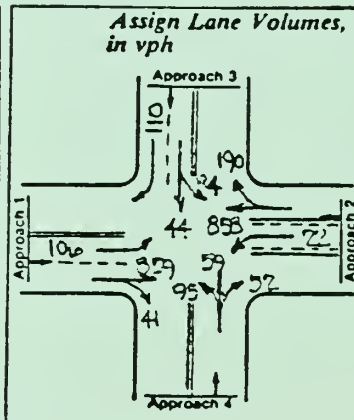
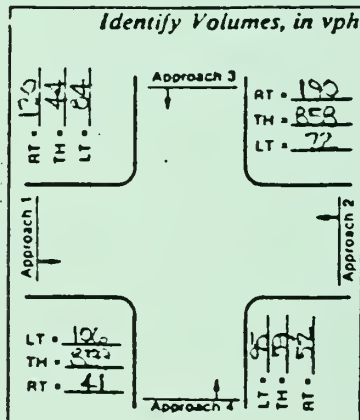
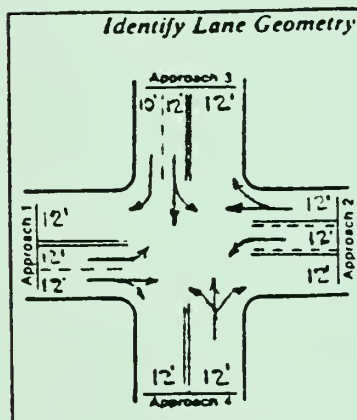
POSSIBLE PHASES APPROACHES 1 & 2

1194	1-one phase only
1324	2-two phase,one left protected,no overlap
1324	3-two phases,one left protected,overlap
1324	4-two phases,both lefts protected,no overlap
1324	5-three phases,both lefts protected,overlap
1351	6-three phases,lead/lag,no overlap
1941	7-three phases,lead/lag,overlap
2252	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

289	1-one phase only
490	8-two phases,directional split

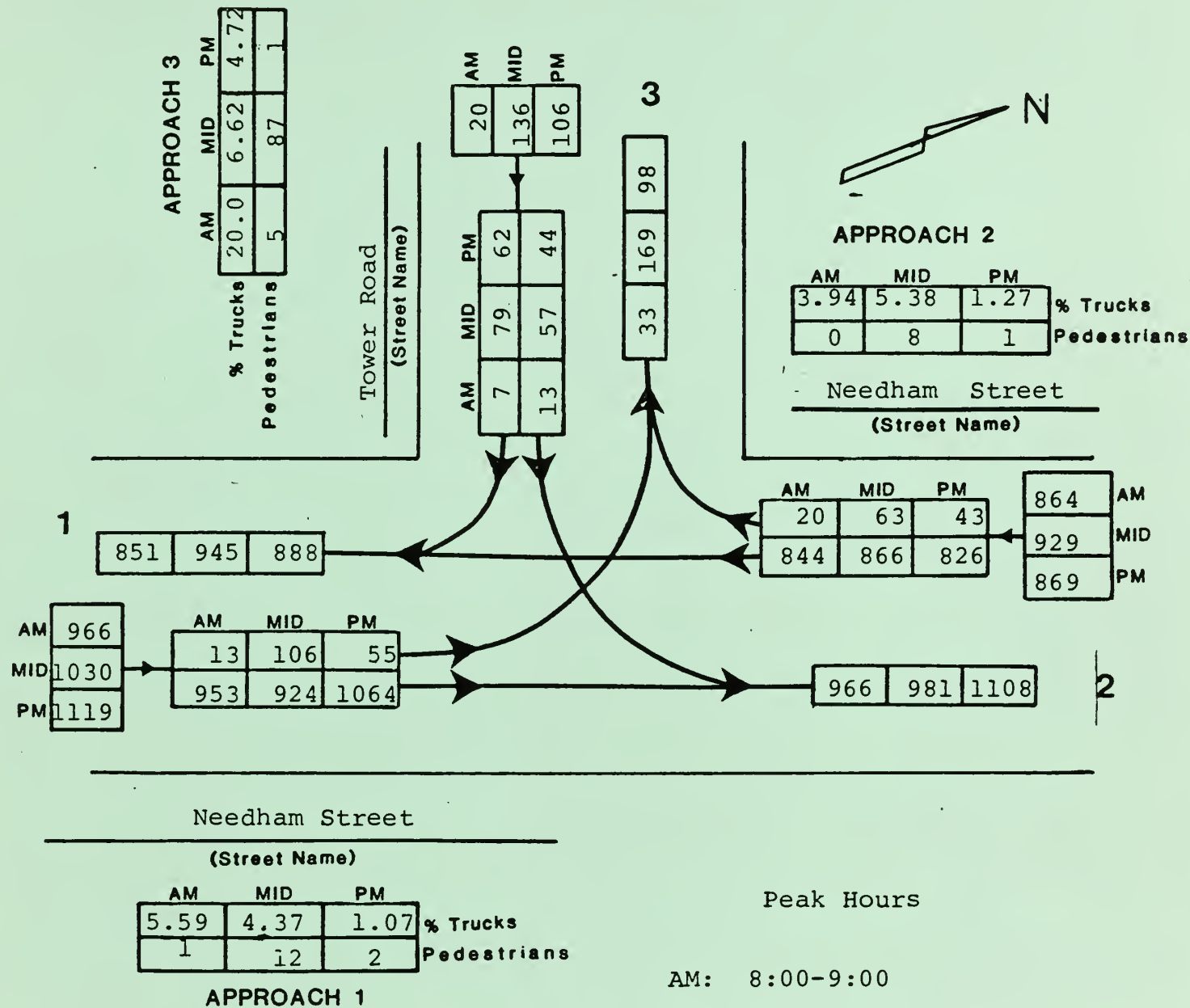
Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1	1	0.82	1483	1800	D
3	1	0.94	1613	1720	E
4	1	0.94	1613	1720	E
2	1	0.94	1613	1720	E
5	1	0.98	1613	1650	E
1	8	0.98	1684	1720	E
6	1	0.99	1640	1650	E
5	8	1.10	1815	1650	F
3	8	1.10	1815	1650	F
4	8	1.10	1815	1650	F
2	8	1.10	1815	1650	F
6	8	1.12	1841	1650	F
7	1	1.35	2230	1650	F
7	8	1.47	2431	1650	F
8	1	1.48	2541	1720	F
8	8	1.66	2742	1650	F



SUMMARY OF VEHICLE MOVEMENTS

Intersection Needham Street @ Tower Road

Date 9/20/84 Day of Week Thursday Weather Fair 60°F Community Newton



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

AM 9/84 ASSUME XLEFT/RIGHT ON TOWER RD

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Tower Rd.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

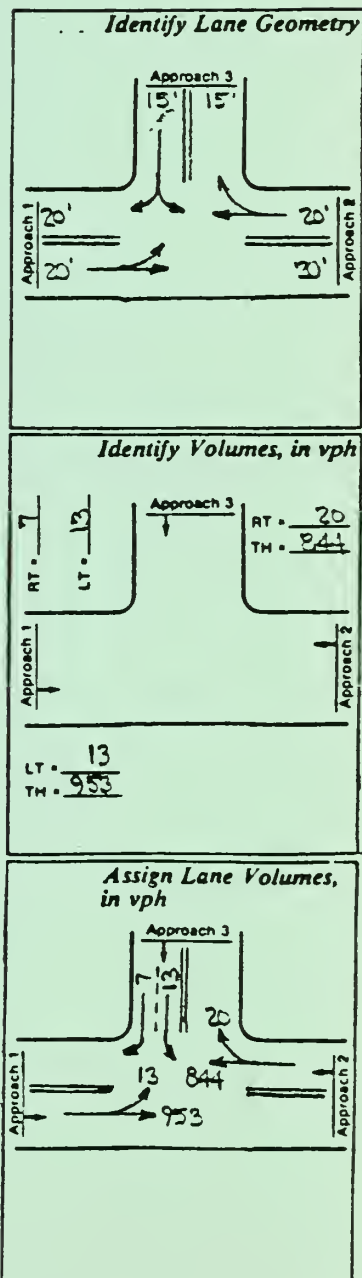
VOLUMES

APPROACH	A: Needham St.			B: Needham St.			C: Tower Rd.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	844	20	13	953	0	13	0	7
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00	
PASSENGER CARS		96.00			94.00			80.00	
PERCENT LT TRU		2.00			3.00			10.00	
PERCENT HV TRU		2.00			3.00			10.00	
PASS CAR/HR	0			14			15	0	8

STEP 1 RIGHT TURNS FROM C: Tower Rd.
 CONFLICTING FLOWS 854
 CRITICAL GAPS 5.0
 CAPACITY 511
 DEMAND 8
 SHARED LANE N
 AVAILABLE RESERVE 503
 DELAY Little or no delay
 LOS A

STEP 2 LEFT TURNS FROM B: Needham St.
 CONFLICTING FLOWS 864
 CRITICAL GAPS 5.0
 CAPACITY 506
 DEMAND 14
 CAPACITY USED 3
 IMPEDANCE FACTOR 0.99
 AVAILABLE RESERVE 492
 DELAY Little or no delay
 LOS A

STEP 3 LEFT TURNS FROM C: Tower Rd.
 CONFLICTING FLOWS 1820
 CRITICAL GAPS 6.5
 CAPACITY 87
 ADJUST FOR IMP 86
 SHARED LANE THRU N
 SHARED LANE RIGHT N
 DEMAND 15
 AVAILABLE RESERVE 71
 DELAY Very long delay
 LOS E



MID 9/84 ASSUME XLEFT/RIGHT ON TOWER RD

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Tower Rd.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

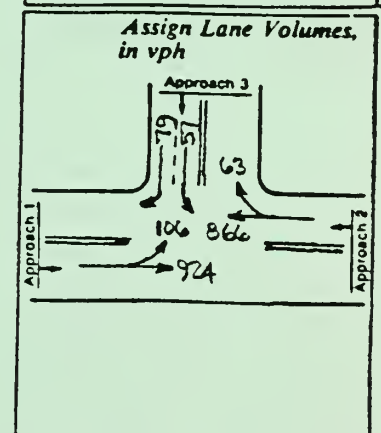
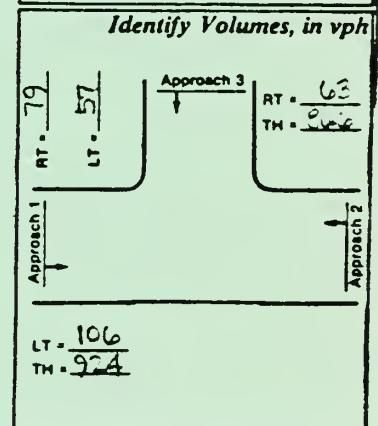
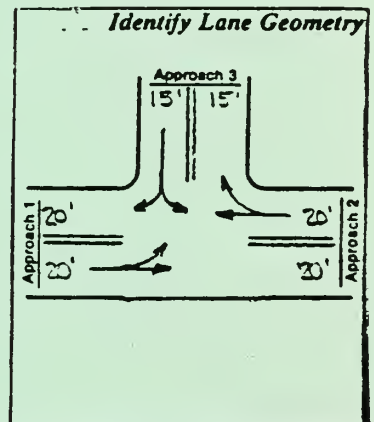
VOLUMES

APPROACH	A: Needham St.			B: Needham St.			C: Tower Rd.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	866	63	106	924	0	57	0	79
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES	0.00			0.00			0.00		
PASSENGER CARS	95.00			96.00			93.00		
PERCENT LT TRU	2.00			2.00			3.00		
PERCENT HV TRU	3.00			2.00			4.00		
PASS CAR/HR	0			109			60	0	83

STEP 1 RIGHT TURNS FROM C: Tower Rd.
 CONFLICTING FLOWS 898
 CRITICAL GAPS 5.0
 CAPACITY 489
 DEMAND 83
 SHARED LANE N
 AVAILABLE RESERVE 406
 DELAY Little or no delay
 LOS A

STEP 2 LEFT TURNS FROM B: Needham St.
 CONFLICTING FLOWS 929
 CRITICAL GAPS 5.0
 CAPACITY 474
 DEMAND 109
 CAPACITY USED 23
 IMPEDANCE FACTOR 0.83
 AVAILABLE RESERVE 365
 DELAY Short traffic delay
 LOS B

STEP 3 LEFT TURNS FROM C: Tower Rd.
 CONFLICTING FLOWS 1928
 CRITICAL GAPS 6.5
 CAPACITY 75
 ADJUST FOR IMP 63
 SHARED LANE THRU N
 SHARED LANE RIGHT N
 DEMAND 60
 AVAILABLE RESERVE 3
 DELAY Very long delay
 LOS E



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

PM 9/84 ASSUME XLEFT/RIGHT ON TOWER RD

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Tower Rd.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

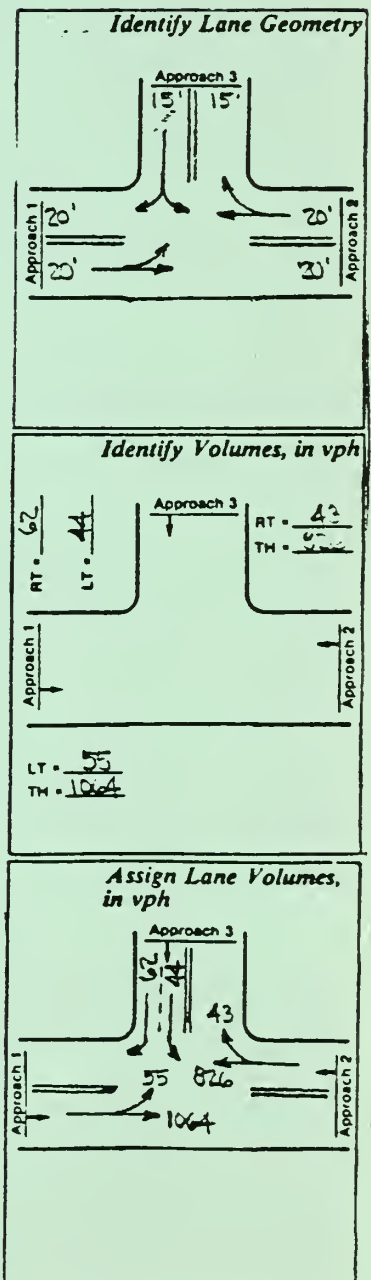
VOLUMES

APPROACH	A: Needham St.			B: Needham St.			C: Tower Rd.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	826	43	55	1064	0	44	0	62
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES	0.00			0.00			0.00		
PASSENGER CARS	99.00			99.00			95.00		
PERCENT LT TRU	0.00			0.00			2.00		
PERCENT HV TRU	1.00			1.00			3.00		
PASS CAR/HR	0			56			46	0	64

STEP 1 RIGHT TURNS FROM	C: Tower Rd.
CONFLICTING FLOWS	848
CRITICAL GAPS	5.0
CAPACITY	514
DEMAND	64
SHARED LANE	N
AVAILABLE RESERVE	450
DELAY	Little or no delay
LOS	A

STEP 2 LEFT TURNS FROM	B: Needham St.
CONFLICTING FLOWS	869
CRITICAL GAPS	5.0
CAPACITY	503
DEMAND	56
CAPACITY USED	11
IMPEDANCE FACTOR	0.93
AVAILABLE RESERVE	448
DELAY	Little or no delay
LOS	A

STEP 3 LEFT TURNS FROM	C: Tower Rd.
CONFLICTING FLOWS	1967
CRITICAL GAPS	6.5
CAPACITY	72
ADJUST FOR IMP	67
SHARED LANE THRU	N
SHARED LANE RIGHT	N
DEMAND	46
AVAILABLE RESERVE	21
DELAY	Very long delay
LOS	E



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

A.M. Install X left/right on Tower Rd.

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Tower Rd.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

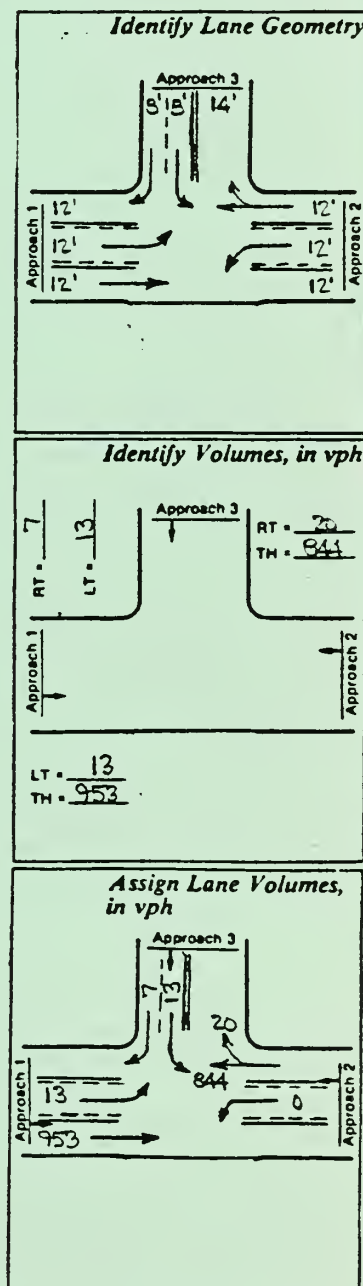
VOLUMES

APPROACH	A: Needham St.			B: Needham St.			C: Tower Rd.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	844	20	13	953	0	13	0	7
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES	0.00			0.00			0.00		
PASSENGER CARS	96.00			94.00			80.00		
PERCENT LT TRU	2.00			3.00			10.00		
PERCENT HV TRU	2.00			3.00			10.00		
PASS CAR/HR	0			14			15	0	8

STEP 1 RIGHT TURNS FROM	C: Tower Rd.
CONFLICTING FLOWS	854
CRITICAL GAPS	5.0
CAPACITY	511
DEMAND	8
SHARED LANE	N
AVAILABLE RESERVE	503
DELAY	Little or no delay
LOS	A

STEP 2 LEFT TURNS FROM	B: Needham St.
CONFLICTING FLOWS	864
CRITICAL GAPS	5.0
CAPACITY	506
DEMAND	14
CAPACITY USED	3
IMPEDANCE FACTOR	0.99
AVAILABLE RESERVE	492
DELAY	Little or no delay
LOS	A

STEP 3 LEFT TURNS FROM	C: Tower Rd.
CONFLICTING FLOWS	1820
CRITICAL GAPS	6.5
CAPACITY	87
ADJUST FOR IMP	86
SHARED LANE THRU	N
SHARED LANE RIGHT	N
DEMAND	15
AVAILABLE RESERVE	71
DELAY	Very long delay
LOS	E



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

MID Install X left/right on Tower Rd.

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Tower Rd.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

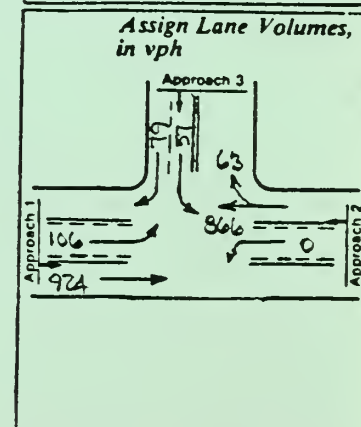
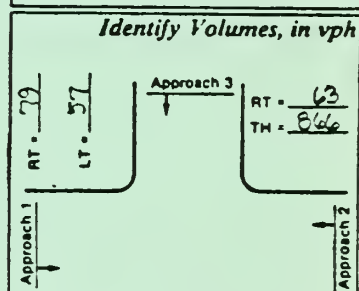
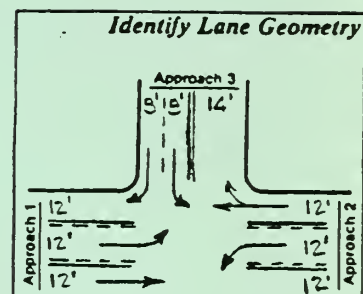
VOLUMES

APPROACH	A: Needham St.			B: Needham St.			C: Tower Rd.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	866	63	106	924	0	57	0	79
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES	0.00			0.00			10.00		
PASSENGER CARS	95.00			96.00			93.00		
PERCENT LT TRU	2.00			2.00			3.00		
PERCENT HV TRU	3.00			2.00			4.00		
PASS CAR/HR	0			109			60	0	83

STEP 1 RIGHT TURNS FROM	C: Tower Rd.
CONFLICTING FLOWS	898
CRITICAL GAPS	5.0
CAPACITY	489
DEMAND	83
SHARED LANE	N
AVAILABLE RESERVE	406
DELAY	Little or no delay
LOS	A

STEP 2 LEFT TURNS FROM	B: Needham St.
CONFLICTING FLOWS	929
CRITICAL GAPS	5.0
CAPACITY	474
DEMAND	109
CAPACITY USED	23
IMPEDANCE FACTOR	0.83
AVAILABLE RESERVE	365
DELAY	Short traffic delay
LOS	B

STEP 3 LEFT TURNS FROM	C: Tower Rd.
CONFLICTING FLOWS	1928
CRITICAL GAPS	6.5
CAPACITY	75
ADJUST FOR IMP	63
SHARED LANE THRU	N
SHARED LANE RIGHT	N
DEMAND	60
AVAILABLE RESERVE	3
DELAY	Very long delay
LOS	E



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

P.M. Install X left/right lanes on Tower Rd.

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Tower Rd.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

VOLUMES

APPROACH	A: Needham St.			B: Needham St.			C: Tower Rd.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	826	43	55	1064	0	44	0	62
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00	
PASSENGER CARS		99.00			99.00			95.00	
PERCENT LT TRU		0.00			0.00			2.00	
PERCENT HV TRU		1.00			1.00			3.00	
PASS CAR/HR	0			56			46	0	64

STEP 1 RIGHT TURNS FROM

CONFLICTING FLOWS

CRITICAL GAPS

CAPACITY

DEMAND

SHARED LANE

AVAILABLE RESERVE

DELAY

LOS

C: Tower Rd.

848

5.0

514

64

N

450

Little or no delay

A

STEP 2 LEFT TURNS FROM

CONFLICTING FLOWS

CRITICAL GAPS

CAPACITY

DEMAND

CAPACITY USED

IMPEDANCE FACTOR

AVAILABLE RESERVE

DELAY

LOS

B: Needham St.

869

5.0

503

56

11

0.93

448

Little or no delay

A

STEP 3 LEFT TURNS FROM

CONFLICTING FLOWS

CRITICAL GAPS

CAPACITY

ADJUST FOR IMP

SHARED LANE THRU

SHARED LANE RIGHT

DEMAND

AVAILABLE RESERVE

DELAY

LOS

C: Tower Rd.

1967

6.5

72

67

N

N

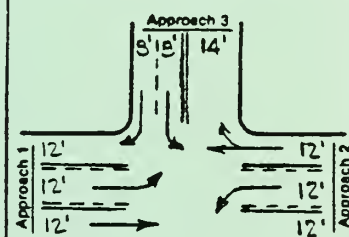
46

21

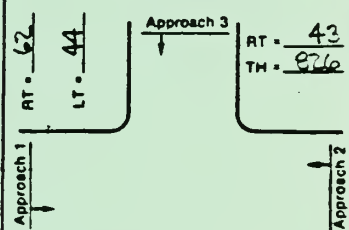
Very long delay

F

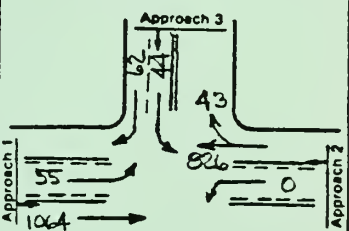
Identify Lane Geometry



Identify Volumes, in vph



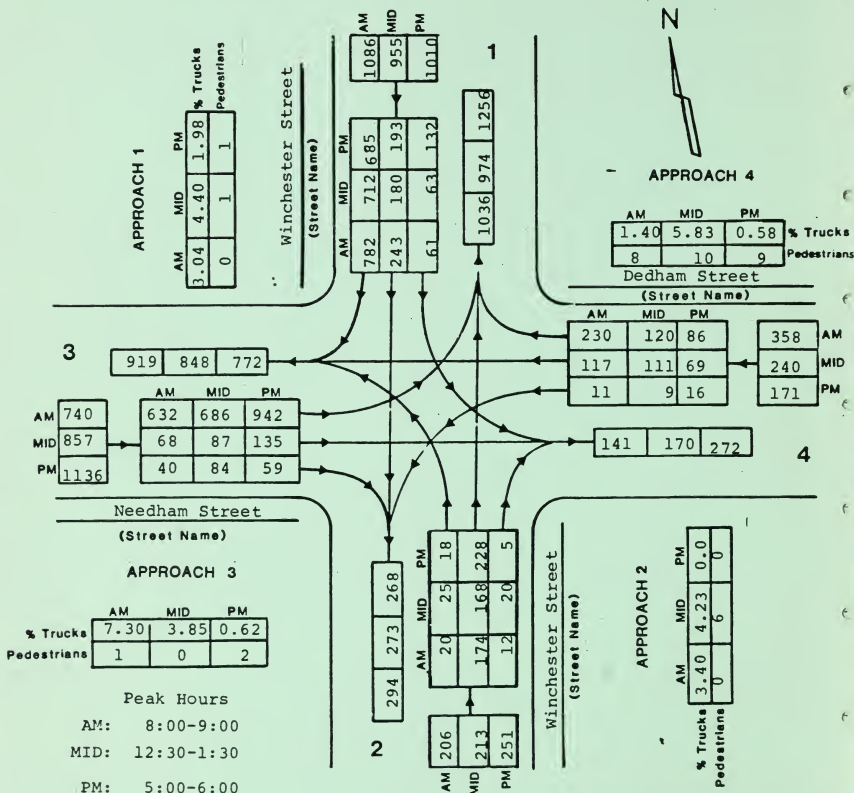
Assign Lane Volumes, in vph



SUMMARY OF VEHICLE MOVEMENTS

Intersection Needham Street @ Winchester Street & Dedham Street

Date 9/20/84 Day of Week Thursday Weather Fair 60° Community Newton



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES

AM 9/84 ASSUME RIGHT TURNS ON DEDHAM ST AND WINCHESTER SB EQUAL 0.

GENERAL CHARACTERISTICS

CONTROLS: STOP

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Winchester NB

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: Winchester SB

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: Y

VOLUMES

APPROACH	A: Needham St.			B: Dedham St.			C: Winchester			D: Winchester		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	632	68	0	11	117	230	20	174	12	63	249	0
PERCENT GRADE	0.00			0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00			0.00	
PASSENGER CARS	93.00				99.00			97.00			97.00	
PERCENT LT TRU	3.00				0.00			1.00			1.00	
PERCENT HV TRU	4.00				1.00			2.00			2.00	
PASS CAR/HK	667			11			21	176	12	65	255	0

STEP 1 RIGHT TURNS FROM	C: Winchester NB			D: Winchester SB		
CONFLICTING FLOWS		68			232	
CRITICAL GAPS		6.0			6.0	
CAPACITY		922			757	
DEMAND		12			0	
CAPACITY USED		1			0	
IMPEDANCE FACTOR		0.99			1.00	
SHARED LANE		Y			N	
AVAILABLE RESERVE		0			757	
DELAY					Little or no delay	
LOS					A	

STEP 2 LEFT TURNS FROM	B: Dedham St.			A: Needham St.		
CONFLICTING FLOWS		68			347	
CRITICAL GAPS		5.0			5.0	
CAPACITY		1121			848	
DEMAND		11			667	
CAPACITY USED		1			79	
IMPEDANCE FACTOR		1.00			0.27	
AVAILABLE RESERVE		1110			181	
DELAY		Little or no delay			Long traffic delay	
LOS		A			D	

STEP 3 THRU MOVES FROM
CONFLICTING FLOWS
CRITICAL GAPS
CAPACITY
ADJUST FOR IMP
DEMAND
CAPACITY USED
IMPEDANCE FACTOR
SHARED LANE LEFT
SHARED LANE RIGHT

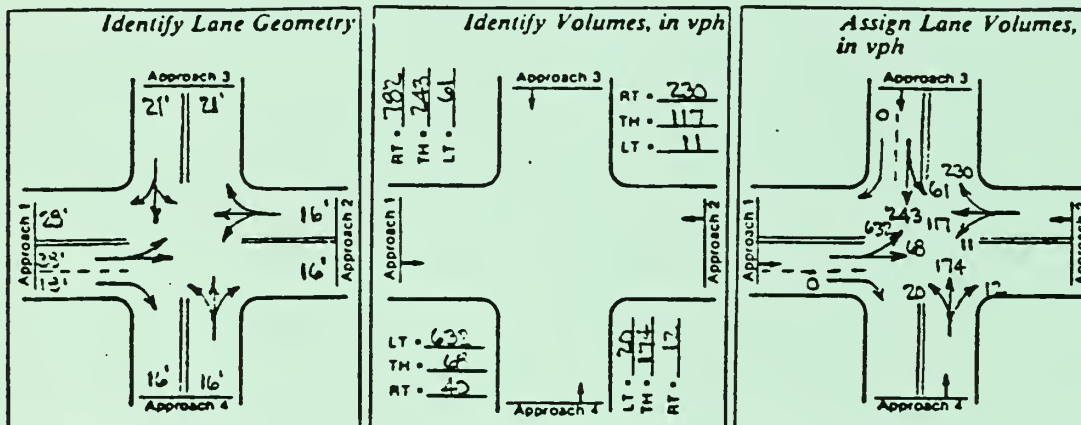
C:Winchester NB
1058
7.0
195
52
178
342
0.00
Y
Y

D:Winchester SB
943
7.0
229
61
255
417
0.00
Y
N

STEP 4 LEFT TURNS FROM
CONFLICTING FLOWS
CRITICAL GAPS
CAPACITY
ADJUST FOR IMP
SHARED LANE THRU
SHARED LANE RIGHT
SHARED LN DEMAND
CAPACITY OF SHARED LN
AVAILABLE RESERVE
DELAY
LOS

C:Winchester NB
1307
7.5
113
0
Y
Y
211
0
-211
Failure
E*

D:Winchester SB
1129
7.5
147
0
Y
N
320
0
-320
Failure
E*



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES

MID 9/84 ASSUME RIGHT TURNS ON NEEDHAM ST AND WINCHESTER SB EQUAL 0.

GENERAL CHARACTERISTICS

CONTROLS: STOP

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Winchester NB

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: Winchester SB

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: Y

VOLUMES

APPROACH	A: Needham St.			B: Dedham St.			C: Winchester			D: Winchester		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	686	87	0	9	111	120	25	168	20	63	180	0
PERCENT GRADE	0.00			0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00			0.00	
PASSENGER CARS		96.00			94.00			96.00			96.00	
PERCENT LT TRU		2.00			3.00			2.00			2.00	
PERCENT HV TRU		2.00			3.00			2.00			2.00	
PASS CAR/HR	707			9			26	173	21	65	185	0

STEP 1 RIGHT TURNS FROM	C: Winchester NB	D: Winchester SB
CONFLICTING FLOWS	87	171
CRITICAL GAPS	6.0	6.0
CAPACITY	901	814
DEMAND	21	0
CAPACITY USED	2	0
IMPEDANCE FACTOR	0.99	1.00
SHARED LANE	Y	N
AVAILABLE RESERVE	0	814
DELAY		Little or no delay
LOS		A

STEP 2 LEFT TURNS FROM	B: Dedham St.	A: Needham St.
CONFLICTING FLOWS	87	231
CRITICAL GAPS	5.0	5.0
CAPACITY	1100	952
DEMAND	9	707
CAPACITY USED	1	74
IMPEDANCE FACTOR	1.00	0.32
AVAILABLE RESERVE	1091	246
DELAY	Little or no delay	Average traffic dela
LOS	A	C

STEP 3 THRU MOVES FROM
CONFLICTING FLOWS
CRITICAL GAPS
CAPACITY
ADJUST FOR IMP
DEMAND
CAPACITY USED
IMPEDANCE FACTOR
SHARED LANE LEFT
SHARED LANE RIGHT

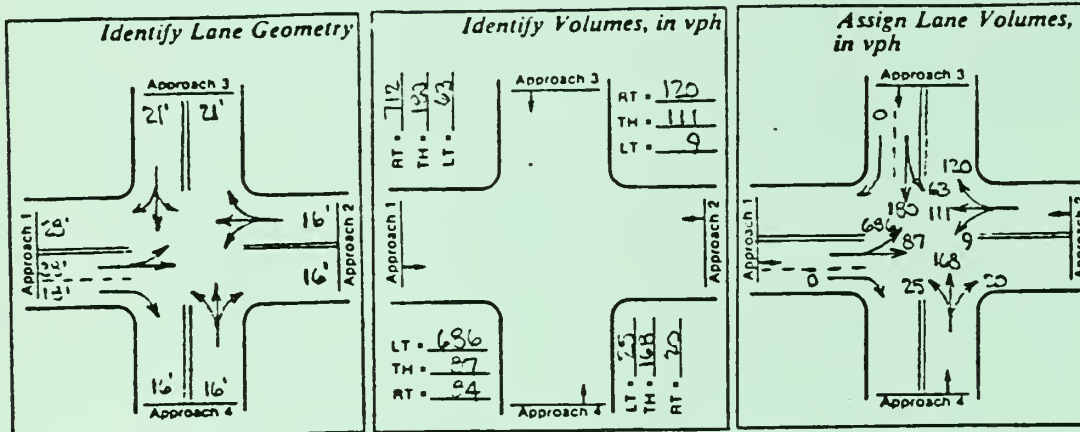
C:Winchester NB
1013
7.0
208
66
173
263
0.00
Y
Y

D:Winchester SB
953
7.0
226
72
185
259
0.00
Y
N

STEP 4 LEFT TURNS FROM
CONFLICTING FLOWS
CRITICAL GAPS
CAPACITY
ADJUST FOR IMP
SHARED LANE THRU
SHARED LANE RIGHT
SHARED LN DEMAND
CAPACITY OF SHARED LN
AVAILABLE RESERVE
DELAY
LOS

C:Winchester NB
1193
7.5
134
0
Y
Y
219
0
-219
Failure
E*

D:Winchester SB
1141
7.5
144
0
Y
N
250
0
-250
Failure
E*



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES

PM 9/84 ASSUME RIGHT TURNS FROM NEEDHAM ST. AND WINCHESTER SB EQUAL 0.

GENERAL CHARACTERISTICS

CONTROLS: STOP

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Winchester St.

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: Winchester St.

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: Y

VOLUMES

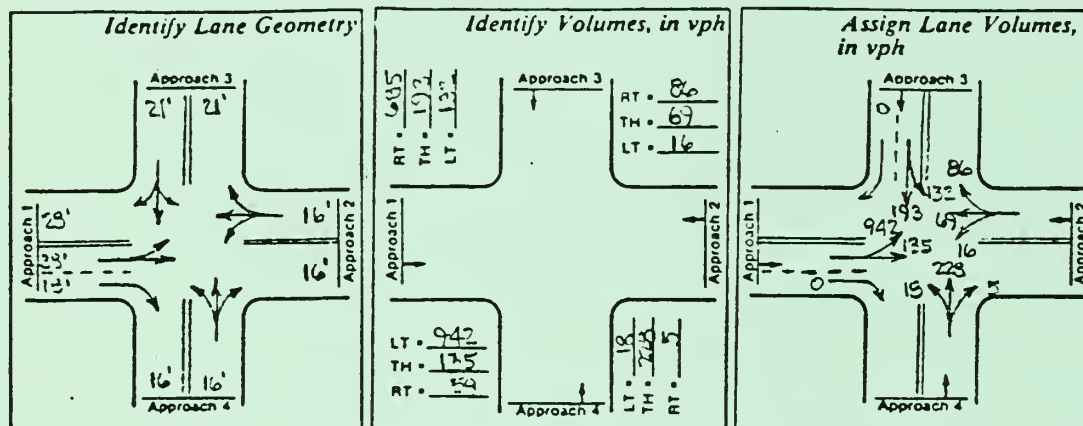
APPROACH	A: Needham St.			B: Dedham St.			C: Winchester			D: Winchester		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	942	135	0	16	69	86	18	228	5	132	193	0
PERCENT GRADE	0.00			0.00			0.00			0.00		
PERCENT CYCLES	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	
PASSENGER CARS	99.00			99.00			100.00			98.00		
PERCENT LT TRU	0.00			0.00			0.00			1.00		
PERCENT HV TRU	1.00			1.00			0.00			1.00		
PASS CAR/HR	951			16			18	228	5	134	196	0

STEP 1 RIGHT TURNS FROM	C: Winchester St.			D: Winchester St.		
CONFLICTING FLOWS	135			112		
CRITICAL GAPS	6.0			6.0		
CAPACITY	850			874		
DEMAND	5			0		
CAPACITY USED	1			0		
IMPEDANCE FACTOR	1.00			1.00		
SHARED LANE	Y			N		
AVAILABLE RESERVE	0			874		
DELAY				Little or no delay		
LOS				A		

STEP 2 LEFT TURNS FROM	B: Dedham St.			A: Needham St.		
CONFLICTING FLOWS	135			155		
CRITICAL GAPS	5.0			5.0		
CAPACITY	1048			1028		
DEMAND	16			951		
CAPACITY USED	2			93		
IMPEDANCE FACTOR	0.99			0.11		
AVAILABLE RESERVE	1032			76		
DELAY	Little or no delay			Very long delay		
LOS	A			E		

	C:Winchester St.	D:Winchester St.
STEP 3 THRU MOVES FROM		
CONFLICTING FLOWS	1248	1205
CRITICAL GAPS	7.0	7.0
CAPACITY	149	159
ADJUST FOR IMP	16	17
DEMAND	228	196
CAPACITY USED	1408	1139
IMPEDANCE FACTOR	0.00	0.00
SHARED LANE LEFT	Y	Y
SHARED LANE RIGHT	Y	N

	C:Winchester St.	D:Winchester St.
STEP 4 LEFT TURNS FROM		
CONFLICTING FLOWS	1441	1438
CRITICAL GAPS	7.5	7.5
CAPACITY	92	93
ADJUST FOR IMP	0	0
SHARED LANE THRU	Y	Y
SHARED LANE RIGHT	Y	N
SHARED LN DEMAND	251	330
CAPACITY OF SHARED LN	0	0
AVAILABLE RESERVE	-251	-330
DELAY	Failure	Failure
LDS	E*	E*



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

AM TOPICS RIGHT TURNS ON APPROACHES 1 & 3 ASSUMED EQUAL TO 0 AS PER EXCLUSIVE
IGHT LANES PROVIDED

STEP ONE OUTPUT

	1	2	3	4
NAME	Needham St.	Dedham St.	Winchester St.	Winchester St.
#THRU LANES	1	2	1	2
AVG WIDTH	10	8	13	8
#LT LANES	1	0	0	0
AVG WIDTH	10	0	0	0
#RT LANES	1	0	1	0
AVG WIDTH	15	0	13	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	632	11	61	20
THRU VOL	68	117	243	174
RT VOL	0	161	0	12
PED VOL	0	0	0	0
TRUCK %	7.3	1.4	3.0	3.4
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	60	60	60	60
CHANGE INT	60	60	60	60
LT CAP ON CI	120	120	120	120
G/C	.67	.67	.32	.32
OP VOL	278	68	186	243
LT CAP ON GR	526	736	198	141
LT TOT CAP	646	856	318	261
LT VOL	632	11	61	20
PASS CHK	t	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.95	0.77	0.96	0.84
LT VOL	714	14	65	25
THRU VOL	77	154	261	214
RT VOL	0	212	0	15

	1	2	3	4
OP VOL	278	68	186	243
PCE LTU	1.00	1.00	1.00	1.00
PCE LTP	1.05	1.20	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B2	714	750
A1	77	77
A2B1	381	383
A3B4	326	339
A4B3	254	259

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B2	714	750
A1	77	77
A2B1	220	221
A3B4	294	305
A4B3	146	149

STEP TEN OUTPUT

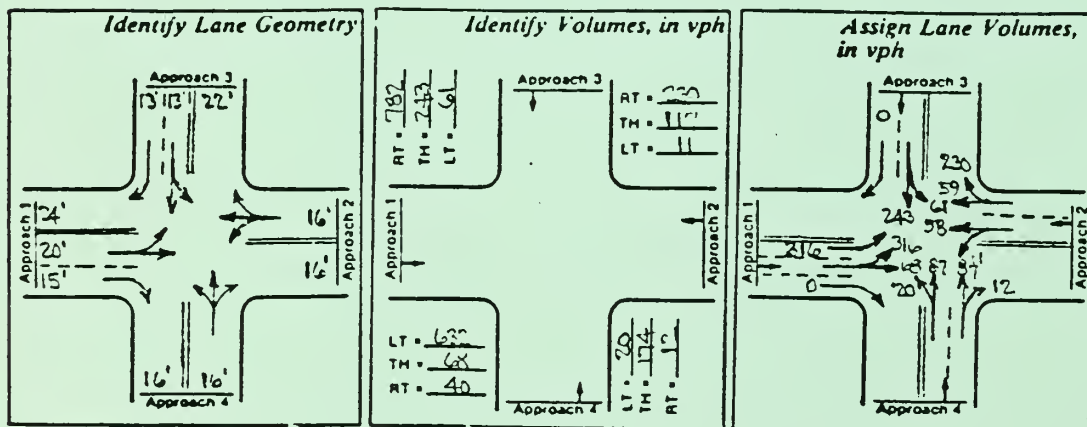
POSSIBLE PHASES APPROACHES 1 & 2

714	1-one phase only
971	2-two phase,one left protected,no overlap
971	3-two phases,one left protected,overlap
971	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

294	1-one phase only
455	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1	1	0.56	1007	1800	A
1	8	0.68	1168	1720	C
8	1	0.74	1265	1720	C
3	1	0.74	1265	1720	C
2	1	0.74	1265	1720	C
8	8	0.86	1426	1650	D
3	8	0.86	1426	1650	D
2	8	0.86	1426	1650	D



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

MID TOPICS RIGHT TURNS ON APPROACHES 1 & 3 ASSUMED EQUAL TO 0 AS PER EXCLUSIVE RIGHT LANES PROVIDED

STEP ONE OUTPUT

	1	2	3	4
NAME	Needham St.	Dedham St.	Winchester St.	Winchester St.
#THRU LANES	1	2	1	2
AVG WIDTH	10	8	13	8
#LT LANES	1	0	0	0
AVG WIDTH	10	0	0	0
#RT LANES	1	0	1	0
AVG WIDTH	15	0	13	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	686	9	63	25
THRU VOL	87	111	180	168
RT VOL	0	120	0	20
PED VOL	0	0	0	0
TRUCK %	3.9	5.8	4.4	4.3
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE (secs)	60	60	60	60
CHANGE INT	60	60	60	60
LT CAP ON CI	120	120	120	120
G/C	.73	.73	.26	.26
OP VOL	231	87	188	180
LT CAP ON GR	645	789	124	132
LT TOT CAP	765	909	244	252
LT VOL	686	9	63	25
PASS CHK	t	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.92	0.89	0.89	0.87
LT VOL	774	11	74	30
THRU VOL	98	132	211	201
RT VOL	0	143	0	24

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	231	87	188	180
PCE LTU	1.00	1.00	1.00	1.00
PCE LTP	1.05	1.20	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B2	774	813
A1	98	98
A2B1	285	288
A3B4	285	300
A4B3	255	261

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B2	774	813
A1	98	98
A2B1	165	166
A3B4	257	270
A4B3	147	151

STEP TEN OUTPUT

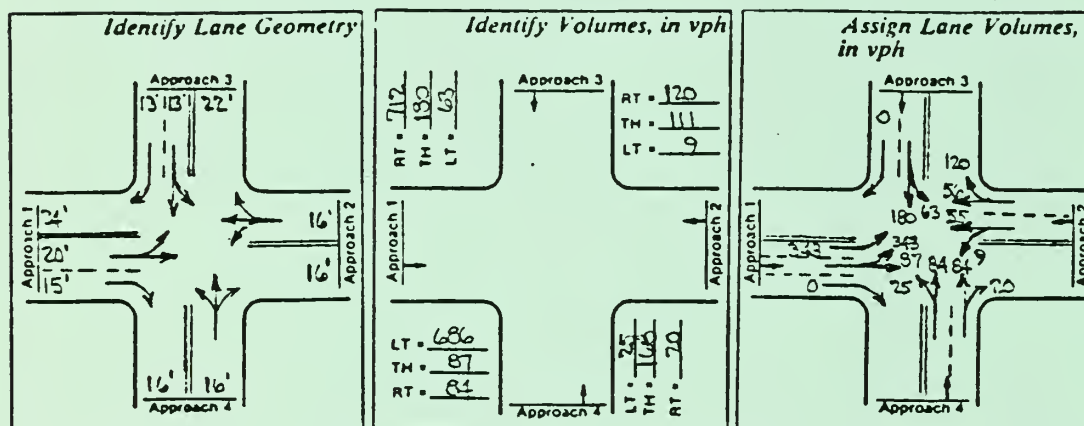
POSSIBLE PHASES APPROACHES 1 & 2

774	1-one phase only
979	2-two phase,one left protected,no overlap
979	3-two phases,one left protected,overlap
979	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

257	1-one phase only
421	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1	1	0.57	1031	1800	B
1	8	0.69	1195	1720	C
8	1	0.72	1236	1720	C
3	1	0.72	1236	1720	C
2	1	0.72	1236	1720	C
8	8	0.85	1400	1650	D
3	8	0.85	1400	1650	D
2	8	0.85	1400	1650	D



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

PM TOPICS RIGHT TURNS ON APPROACHES 1 & 3 ASSUMED EQUAL TO 0 AS PER EXCLUSIVE RIGHT LANES PROVIDED

STEP ONE OUTPUT

	1	2	3	4
NAME	Needham St.	Dedham St.	Winchester St.	Winchester St.
#THRU LANES	1	2	1	2
AVG WIDTH	10	8	13	8
#LT LANES	1	0	0	0
AVG WIDTH	10	0	0	0
#RT LANES	1	0	1	0
AVG WIDTH	15	0	13	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	942	16	132	18
THRU VOL	135	69	193	228
RT VOL	0	86	0	5
PED VOL	0	0	0	0
TRUCK %	0.6	0.6	2.0	0.0
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	60	60	60	60
CHANGE INT	60	60	60	60
LT CAP ON CI	120	120	120	120
G/C	.74	.74	.25	.25
OP VOL	155	135	233	193
LT CAP ON GR	733	753	67	107
LT TOT CAP	853	873	187	227
LT VOL	942	16	132	18
PASS CHK	f	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.93	0.84	0.92	0.73
LT VOL	1019	19	146	25
THRU VOL	146	83	214	312
RT VOL	0	103	0	7

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	155	135	233	193
PCE LTU	1.00	1.00	1.00	1.00
PCE LTP	1.05	1.20	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

UNPROTECT LT PROTECT LT

B2	1019	1070
A1	146	146
A2B1	205	209
A3B4	360	390
A4B3	344	349

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B2	1019	1070
A1	146	146
A2B1	118	120
A3B4	324	351
A4B3	199	201

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

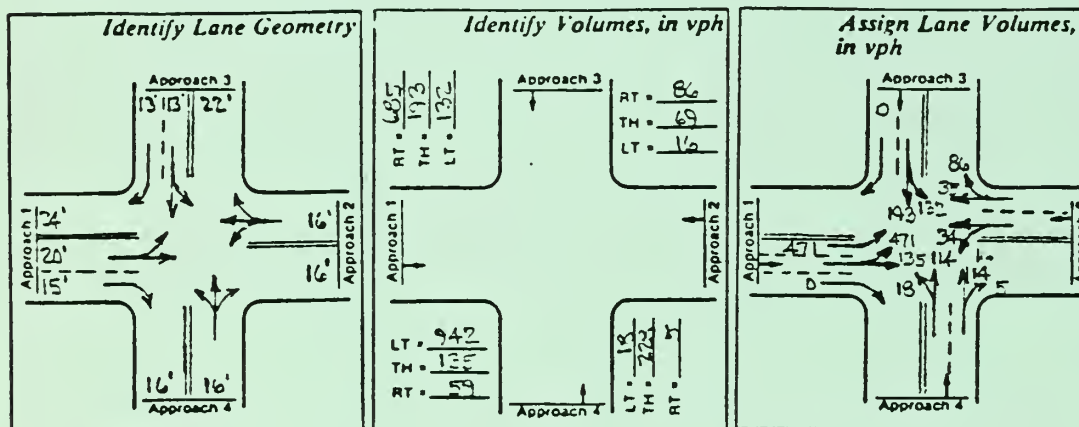
1019	1-one phase only
1216	2-two phase,one left protected,no overlap
1191	3-two phases,one left protected,overlap
1191	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

324	1-one phase only
552	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1*	1	0.75	1343	1800	C
8	1	0.88	1515	1720	D
3	1	0.88	1515	1720	D
2	1	0.90	1540	1720	E
1*	8	0.91	1571	1720	E
8	8	1.06	1743	1650	F
3	8	1.06	1743	1650	F
2	8	1.07	1768	1650	F

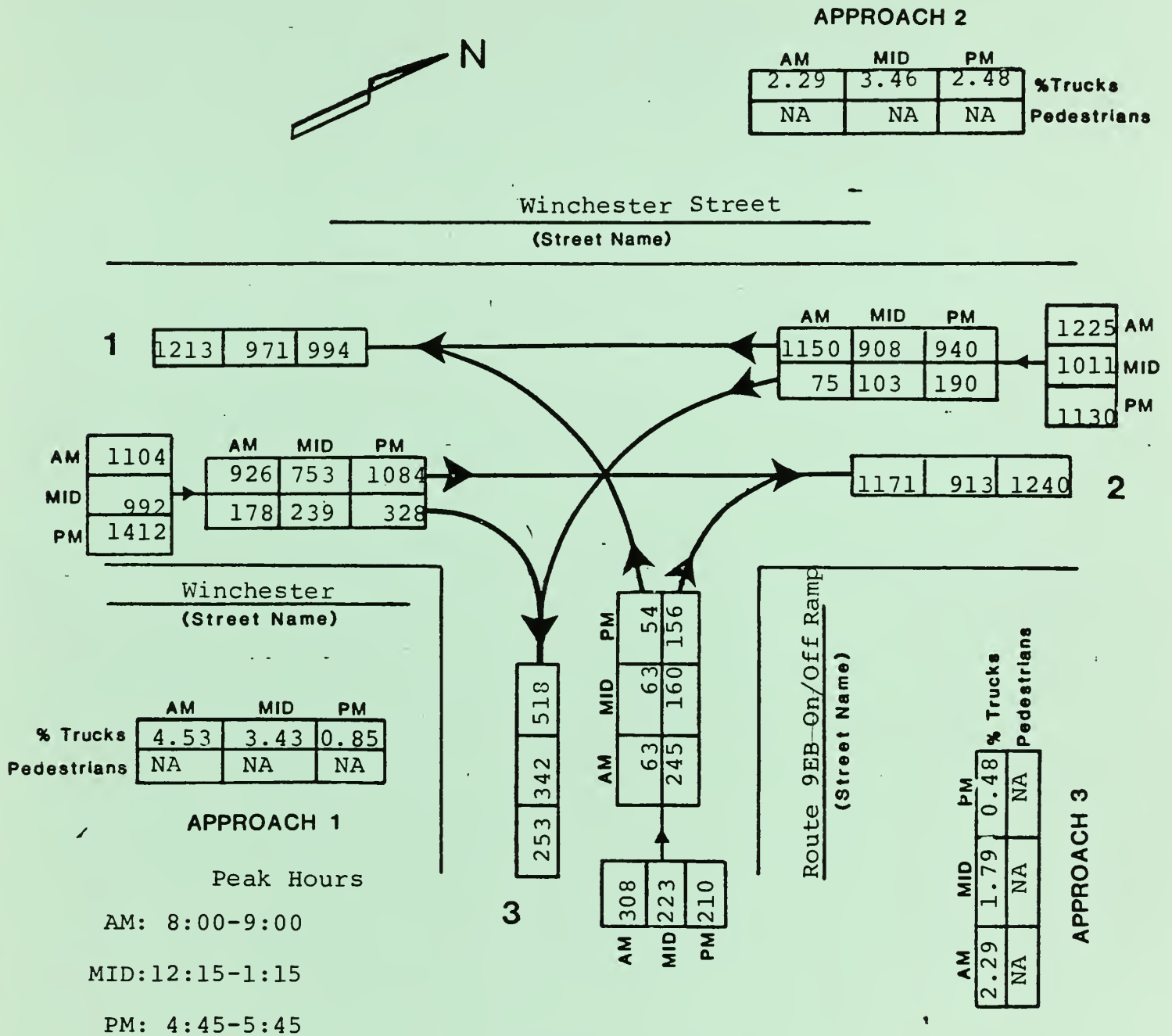
* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above



SUMMARY OF VEHICLE MOVEMENTS

Intersection Winchester Street at Route 9 Eastbound On/off Ramp

Date 10/17/84 Day of Week Wednesday Weather Fair; 60°F Community Newton



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

A.M. Oct. '84

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Rte. 9 EB ramp

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

VOLUMES

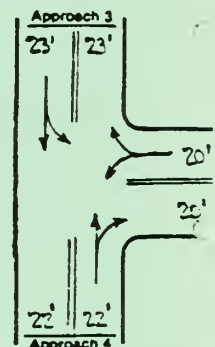
APPROACH	A: Winchester			B: Winchester			C: Rte. 9 EB r		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	926	178	75	1150	0	63	0	245
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00	
PASSENGER CARS		95.00			98.00			97.00	
PERCENT LT TRU		2.00			1.00			1.00	
PERCENT HV TRU		3.00			1.00			2.00	
PASS CAR/HR	0			76			65	0	251

STEP 1 RIGHT TURNS FROM	C:Rte. 9 EB ramp
CONFLICTING FLOWS	1015
CRITICAL GAPS	5.0
CAPACITY	435
SHARED LANE	Y

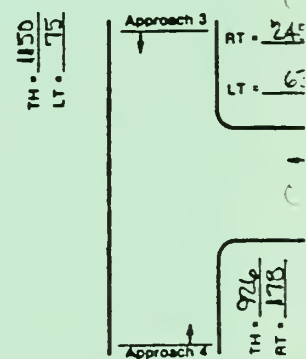
STEP 2 LEFT TURNS FROM	B:Winchester St.
CONFLICTING FLOWS	1104
CRITICAL GAPS	5.0
CAPACITY	398
DEMAND	76
CAPACITY USED	19
IMPEDANCE FACTOR	0.87
AVAILABLE RESERVE	322
DELAY	Short traffic delay
LOS	B

STEP 3 LEFT TURNS FROM	C:Rte. 9 EB ramp
CONFLICTING FLOWS	2240
CRITICAL GAPS	6.5
CAPACITY	50
ADJUST FOR IMP	43
SHARED LANE THRU	Y
SHARED LANE RIGHT	Y
SHARED LN DEMAND	316
CAPACITY OF SHARED LN	153
AVAILABLE RESERVE	-163
DELAY	Failure
LOS	E*

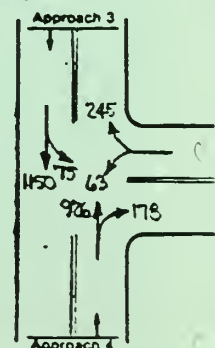
Identify Lane Geomet



Identify Volumes, in v



Assign Lane Volum... in vph



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

MID Oct. '84

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Rte 9 EB-ramp

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

VOLUMES

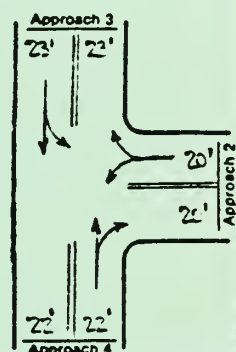
APPROACH	A: Winchester			B: Winchester			C: Rte 9 EB-ra		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	753	239	103	908	0	54	0	156
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00	
PASSENGER CARS		97.00			96.00			100.00	
PERCENT LT TRU		1.00			2.00			0.00	
PERCENT HV TRU		2.00			2.00			0.00	
PASS CAR/HR	0			106			54	0	156

STEP 1 RIGHT TURNS FROM	C: Rte 9 EB-ramp
CONFLICTING FLOWS	873
CRITICAL GAPS	5.0
CAPACITY	501
SHARED LANE	Y

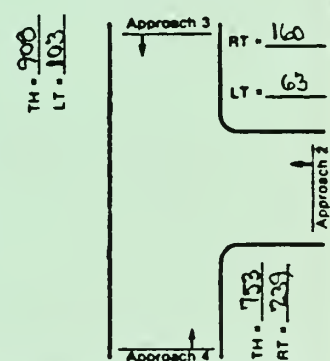
STEP 2 LEFT TURNS FROM	B: Winchester St.
CONFLICTING FLOWS	992
CRITICAL GAPS	5.0
CAPACITY	445
DEMAND	106
CAPACITY USED	24
IMPEDANCE FACTOR	0.83
AVAILABLE RESERVE	339
DELAY	Short traffic delay
LOS	B

STEP 3 LEFT TURNS FROM	C: Rte 9 EB-ramp
CONFLICTING FLOWS	1884
CRITICAL GAPS	6.5
CAPACITY	80
ADJUST FOR IMP	66
SHARED LANE THRU	Y
SHARED LANE RIGHT	Y
SHARED LN DEMAND	210
CAPACITY OF SHARED LN	186
AVAILABLE RESERVE	-24
DELAY	Failure
LOS	E*

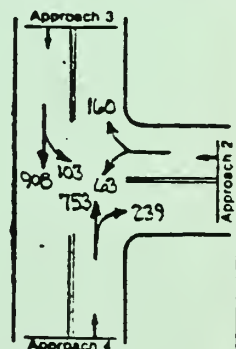
Identify Lane Geometry



Identify Volumes, in vph



Assign Lane Volumes, in vph



OCT. 84

CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

P.M. 4:45

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Ramp to Rte. 9

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

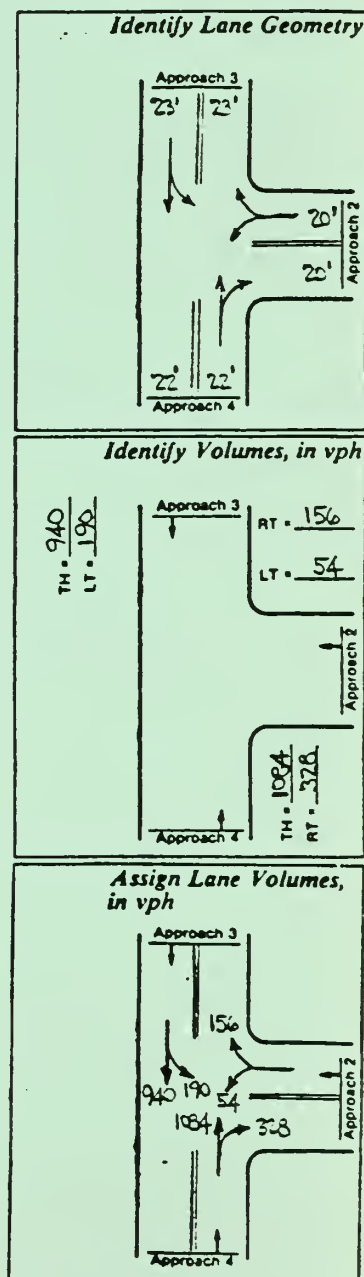
VOLUMES

APPROACH	A: Winchester			B: Winchester			C: Ramp to Rte		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	1084	328	190	940	0	54	0	156
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00	
PASSENGER CARS		99.00			98.00			100.00	
PERCENT LT TRU		0.00			1.00			0.00	
PERCENT HV TRU		1.00			1.00			0.00	
PASS CAR/HR	0			193			54	0	156

STEP 1 RIGHT TURNS FROM	C: Ramp to Rte. 9
CONFLICTING FLOWS	1248
CRITICAL GAPS	5.0
CAPACITY	344
SHARED LANE	Y

STEP 2 LEFT TURNS FROM	B: Winchester St.
CONFLICTING FLOWS	1412
CRITICAL GAPS	5.0
CAPACITY	292
DEMAND	193
CAPACITY USED	66
IMPEDANCE FACTOR	0.41
AVAILABLE RESERVE	100
DELAY	Very long delay
LOS	E

STEP 3 LEFT TURNS FROM	C: Ramp to Rte. 9
CONFLICTING FLOWS	2378
CRITICAL GAPS	6.5
CAPACITY	42
ADJUST FOR IMP	17
SHARED LANE THRU	Y
SHARED LANE RIGHT	Y
SHARED LN DEMAND	210
CAPACITY OF SHARED LN	58
AVAILABLE RESERVE	-152
DELAY	Failure
LOS	E*



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

AM TOPICS

STEP ONE OUTPUT

	1	2	3	4
NAME	Winchester St.	Centre St.	NONE	RTE 9 EBrmp
#THRU LANES	2	1	1	0
AVG WIDTH	10	12	8	0
#LT LANES	0	1	0	1
AVG WIDTH	0	11	0	10
#RT LANES	0	0	0	1
AVG WIDTH	0	0	0	10

STEP TWO OUTPUT

	1	2	3	4
LT VOL	0	75	0	63
THRU VOL	926	1150	0	0
RT VOL	178	0	0	245
PED VOL	0	0	0	0
TRUCK %	4.5	2.3	0.0	2.9
BUS STOP	1	1	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	60	60	60	60
CHANGE INT	60	60	60	60
LT CAP ON CI	120	120	120	120
G/C	.82	.82	.17	.17
OP VOL	1150	1104	245	0
LT CAP ON GR	0	0	0	204
LT TOT CAP	120	120	120	324
LT VOL	0	75	0	63
PASS CHK	t	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.93	0.96	0.00	0.84
LT VOL	0	80	0	77
THRU VOL	1045	1230	0	0
RT VOL	200	0	0	300

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	1150	1104	245	0
PCE LTU	6.00	6.00	1.00	1.00
PCE LTP	1.20	1.05	1.20	1.05
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B1	480	84
A2	1230	1230
B3	77	81
A1B2	1245	1245

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B1	480	84
A2	1230	1230
B3	77	81
A4**	300	300
A1B2	654	654

** The critical lane volume occurs in the exclusive right turn lane(s)

STEP TEN OUTPUT

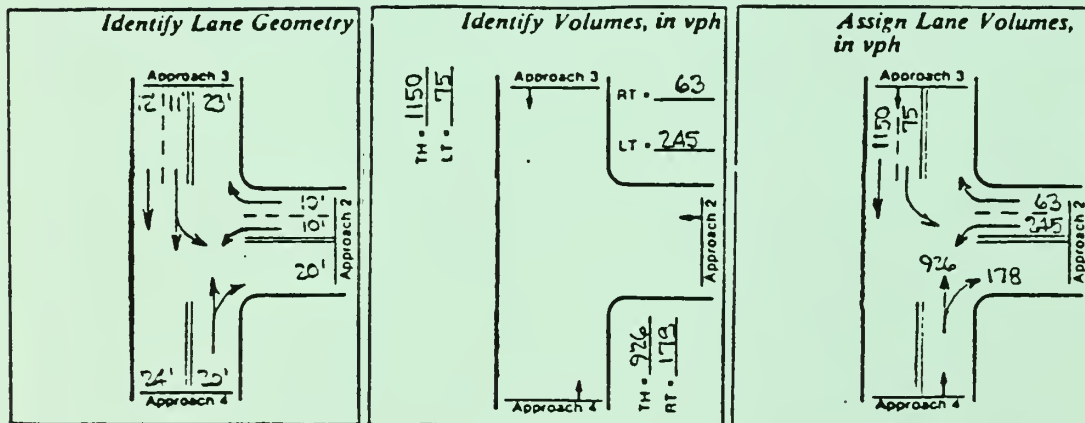
POSSIBLE PHASES APPROACHES 1 & 2

1230	1-one phase only
1314	2-two phase,one left protected,no overlap
1230	3-two phases,one left protected,overlap
1883	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

300	1-one phase only
381	2-two phase,one left protected,no overlap
300	3-two phases,one left protected,overlap
300	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1	1	0.85	1530	1800	D
1	8	0.89	1530	1720	D
3	1	0.89	1530	1720	D
1	3	0.89	1530	1720	D
3	3	0.93	1530	1650	E
3	8	0.93	1530	1650	E
1	2	0.94	1611	1720	E
2	1	0.94	1614	1720	E
3	2	0.98	1611	1650	E
2	8	0.98	1614	1650	E
2	3	0.98	1614	1650	E
2	2	1.03	1695	1650	F
8	1	1.27	2183	1720	F
8	3	1.32	2183	1650	F
8	8	1.32	2183	1650	F
8	2	1.37	2264	1650	F



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN
MID TOPICS

STEP ONE OUTPUT

NAME	1 Winchester St.	2 Centre St.	3 NONE	4 RTE 9 EBrmp
#THRU LANES	2	1	1	0
AVG WIDTH	10	12	8	0
#LT LANES	0	1	0	1
AVG WIDTH	0	11	0	10
#RT LANES	0	0	0	1
AVG WIDTH	0	0	0	10

STEP TWO OUTPUT

	1	2	3	4
LT VOL	0	103	0	63
THRU VOL	753	908	0	0
RT VOL	239	0	0	160
PED VOL	0	0	0	0
TRUCK %	3.4	3.5	0.0	1.8
BUS STOP	1	1	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE (secs)	60	60	60	60
CHANGE INT	60	60	60	60
LT CAP ON CI	120	120	120	120
G/C	.85	.85	.14	.14
OP VOL	908	992	160	0
LT CAP ON GR	112	28	8	168
LT TOT CAP	232	148	128	288
LT VOL	0	103	0	63
PASS CHK	t	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.90	0.90	0.00	0.90
LT VOL	0	118	0	71
THRU VOL	870	1049	0	0
RT VOL	275	0	0	181

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	908	992	160	0
PCE LTU	4.00	4.00	1.00	1.00
PCE LTP	1.20	1.05	1.20	1.05
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B1	474	124
A2	1049	1049
B3	71	75
A1B2	1144	1144

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B1	474	124
A2	1049	1049
B3	71	75
A4**	181	181
A1B2	601	601

** The critical lane volume occurs in the exclusive right turn lane(s)

STEP TEN OUTPUT

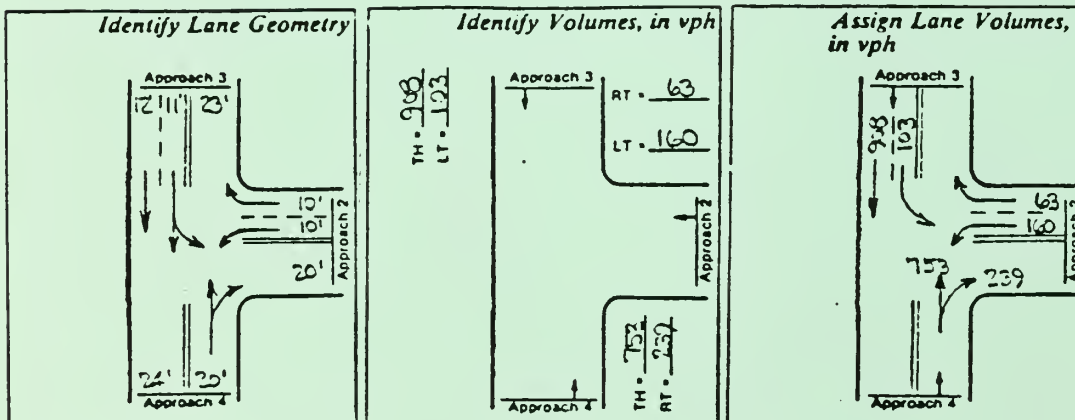
POSSIBLE PHASES APPROACHES 1 & 2

1049	1-one phase only
1173	2-two phase,one left protected,no overlap
1049	3-two phases,one left protected,overlap
1649	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

181	1-one phase only
256	2-two phase,one left protected,no overlap
181	3-two phases,one left protected,overlap
181	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1	1	0.68	1230	1800	C
1	8	0.71	1230	1720	C
3	1	0.71	1230	1720	C
1	3	0.71	1230	1720	C
3	3	0.75	1230	1650	C
3	8	0.75	1230	1650	C
1	2	0.76	1304	1720	C
2	1	0.79	1354	1720	D
3	2	0.79	1304	1650	D
2	8	0.82	1354	1650	D
2	3	0.82	1354	1650	D
2	2	0.87	1429	1650	D
8	1	1.06	1830	1720	F
8	3	1.11	1830	1650	F
8	8	1.11	1830	1650	F
8	2	1.15	1905	1650	F



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

PM TOPICS

STEP ONE OUTPUT

	1	2	3	4
NAME	Winchester St.	Centre St.	NONE	RTE 9 EBrmd
#THRU LANES	2	1	1	0
AVG WIDTH	10	12	8	0
#LT LANES	0	1	0	1
AVG WIDTH	0	11	0	10
#RT LANES	0	0	0	1
AVG WIDTH	0	0	0	10

STEP TWO OUTPUT

	1	2	3	4
LT VOL	0	190	0	54
THRU VOL	1084	940	0	0
RT VOL	328	0	0	156
PED VOL	0	0	0	0
TRUCK %	0.9	2.5	0.0	0.5
BUS STOP	1	1	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	60	60	60	60
CHANGE INT	60	60	60	60
LT CAP ON CI	120	120	120	120
G/C	.85	.85	.14	.14
OP VOL	940	1412	156	0
LT CAP ON GR	80	0	12	168
LT TOT CAP	200	120	132	288
LT VOL	0	190	0	54
PASS CHK	t	f	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.92	0.96	0.00	0.95
LT VOL	0	203	0	57
THRU VOL	1193	1008	0	0
RT VOL	360	0	0	165

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	940	1412	156	0
PCE LTU	4.00	6.00	1.00	1.00
PCE LTP	1.20	1.05	1.20	1.05
PCE RT	1.00	1.00	1.00	1.00

UNPROTECT LT PROTECT LT

B1	1217	213
A2	1008	1008
B3	57	60
A1B2	1553	1553

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B1	1217	213
A2	1008	1008
B3	57	60
A4**	165	165
A1B2	815	815

** The critical lane volume occurs in the exclusive right turn lane(s)

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

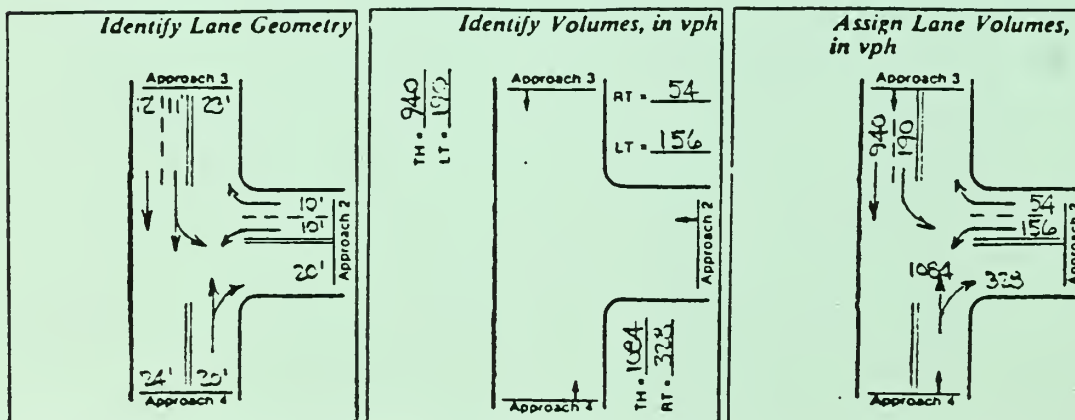
1217	1-one phase only
1221	2-two phase,one left protected,no overlap
1028	3-two phases,one left protected,overlap
1823	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

165	1-one phase only
225	2-two phase,one left protected,no overlap
165	3-two phases,one left protected,overlap
165	8-two phases,directional split

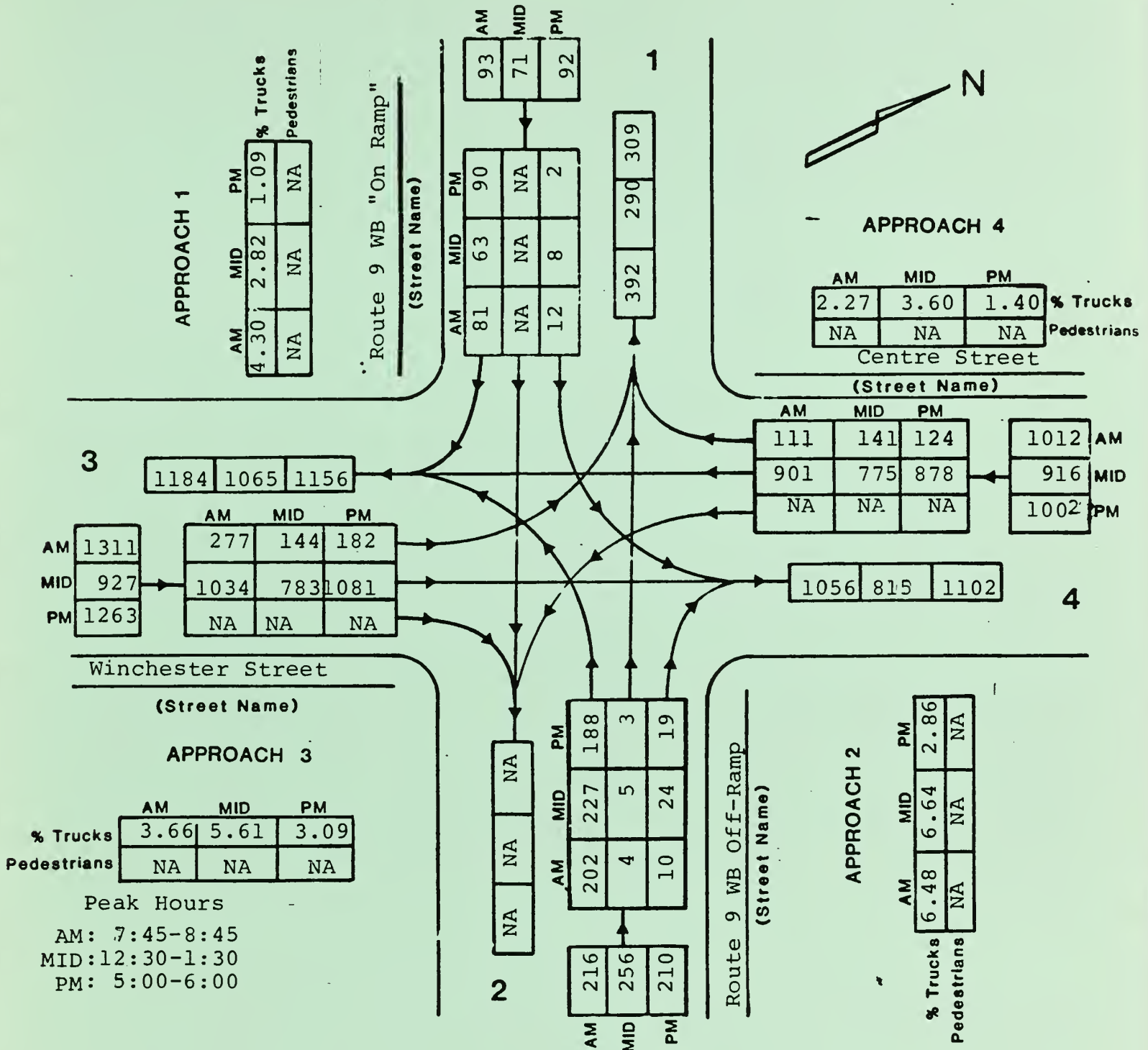
Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
3	1	0.69	1193	1720	C
3	3	0.72	1193	1650	C
3	8	0.72	1193	1650	C
3	2	0.76	1253	1650	C
1*	1	0.77	1382	1800	C
1*	3	0.80	1382	1720	D
1*	8	0.80	1382	1720	D
2	1	0.81	1386	1720	D
1*	2	0.84	1442	1720	D
2	3	0.84	1386	1650	D
2	8	0.84	1386	1650	D
2	2	0.88	1446	1650	D
8	1	1.16	1988	1720	F
8	3	1.20	1988	1650	F
8	8	1.20	1988	1650	F
8	2	1.24	2048	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above



SUMMARY OF VEHICLE MOVEMENTS

Intersection Centre Street/Winchester Street at Route 9 Westbound On/Off
 Ramps Fair to Partly
 Date 10/16/84 Day of Week Tuesday Weather Cloudy 60°F Community Newton



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES

A.M. Oct. 1984

GENERAL CHARACTERISTICS

CONTROLS: STOP

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Rte 9 WB Off-r

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: Rte. 9 On-ramp

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

VOLUMES

APPROACH	A: Winchester			B: Centre St.			C: Rte 9 WB Off-r			D: Rte. 9 On-r		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	277	1034	0	0	901	111	202	4	10	12	0	81
PERCENT GRADE	0.00			0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00			0.00	
PASSENGER CARS		96.00			98.00			94.00			96.00	
PERCENT LT TRU		2.00			1.00			3.00			2.00	
PERCENT HV TRU		2.00			1.00			3.00			2.00	
PASS CAR/HR	285			0			211	4	10	12	0	83

STEP 1 RIGHT TURNS FROM

C:Rte 9 WB Off-r

D:Rte. 9 On-ramp

CONFLICTING FLOWS

1034

957

CRITICAL GAPS

6.0

6.0

CAPACITY

289

317

DEMAND

10

83

CAPACITY USED

4

26

IMPEDANCE FACTOR

0.98

0.80

SHARED LANE

Y

N

AVAILABLE RESERVE

0

234

DELAY

Average traffic dela

LOS

C

STEP 2 LEFT TURNS FROM

B:Centre St.

A:Winchester St.

CONFLICTING FLOWS

1034

1012

CRITICAL GAPS

5.0

5.0

CAPACITY

427

436

DEMAND

0

285

CAPACITY USED

0

65

IMPEDANCE FACTOR

1.00

0.41

AVAILABLE RESERVE

427

151

DELAY

Little or no delay

Long traffic delay

LOS

A

D

N.A.

STEP 3 THRU MOVES FROM
CONFLICTING FLOWS
CRITICAL GAPS
CAPACITY
ADJUST FOR IMP
DEMAND
CAPACITY USED
IMPEDANCE FACTOR
SHARED LANE LEFT
SHARED LANE RIGHT
AVAILABLE RESERVE
DELAY
LOS

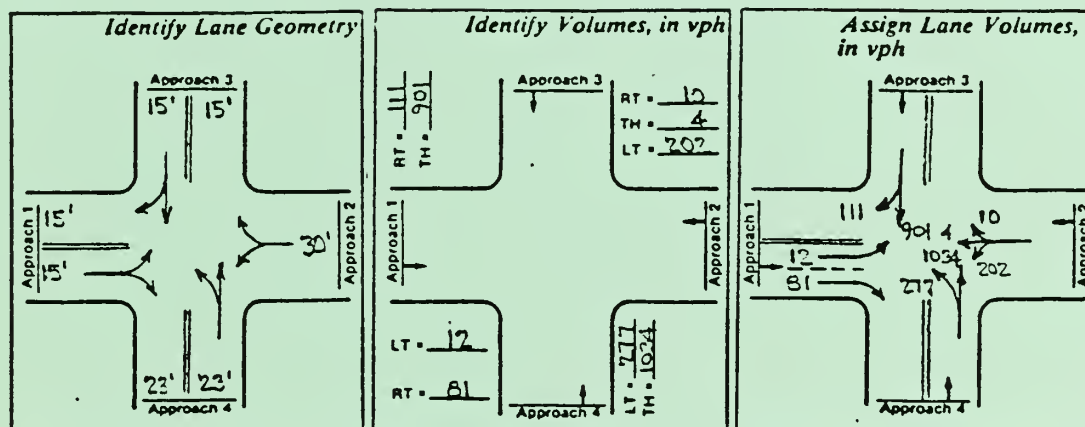
C:Rte 9 WB Off-r
2323
7.0
33
14
4
30
0.77
Y
Y
0

D:Rte. 9 On-ramp
2268
7.0
36
15
0
0
1.00
N
N
0
Very long delay
E

STEP 4 LEFT TURNS FROM
CONFLICTING FLOWS
CRITICAL GAPS
CAPACITY
ADJUST FOR IMP
SHARED LANE THRU
SHARED LANE RIGHT
DEMAND
SHARED LN DEMAND
CAPACITY OF SHARED LN
AVAILABLE RESERVE
DELAY
LOS

C:Rte 9 WB Off-r
2404
7.5
22
7
Y
Y
211
226
8
-218
Failure
E*

D:Rte. 9 On-ramp
2282
7.5
26
8
N
N
12
0
0
-4
Failure
E*



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES

MID Oct. '84

GENERAL CHARACTERISTICS

CONTROLS: STOP

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Rte. 9 WB Off-

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: Rte. 9 On-ramp

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

VOLUMES

APPROACH	A: Winchester			B: Centre St.			C: Rte. 9 WB			D: Rte. 9 On-r		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	144	783	0	0	775	141	227	5	24	8	0	63
PERCENT GRADE	0.00			0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00			0.00	
PASSENGER CARS		94.00			96.00			93.00			97.00	
PERCENT LT TRU		3.00			2.00			3.00			1.00	
PERCENT HV TRU		3.00			2.00			4.00			2.00	
PASS CAR/HR	150			0			239	5	25	8	0	65

STEP 1 RIGHT TURNS FROM

C: Rte. 9 WB Off-

D: Rte. 9 On-ramp

CONFLICTING FLOWS	783	846
CRITICAL GAPS	6.0	6.0
CAPACITY	391	363
DEMAND	25	65
CAPACITY USED	6	18
IMPEDANCE FACTOR	0.96	0.88
SHARED LANE	Y	N
AVAILABLE RESERVE	0	298
DELAY		Average traffic dela
LOS		C

STEP 2 LEFT TURNS FROM

B: Centre St.

A: Winchester St.

CONFLICTING FLOWS	783	916
CRITICAL GAPS	5.0	5.0
CAPACITY	548	480
DEMAND	0	150
CAPACITY USED	0	31
IMPEDANCE FACTOR	1.00	0.76
AVAILABLE RESERVE	548	330
DELAY	Little or no delay	Short traffic delay
LOS	A	B

N.A.

STEP 3 THRU MOVES FROM
CONFLICTING FLOWS
CRITICAL GAPS
CAPACITY
ADJUST FOR IMP
DEMAND
CAPACITY USED
IMPEDANCE FACTOR
SHARED LANE LEFT
SHARED LANE RIGHT
AVAILABLE RESERVE
DELAY
LOS

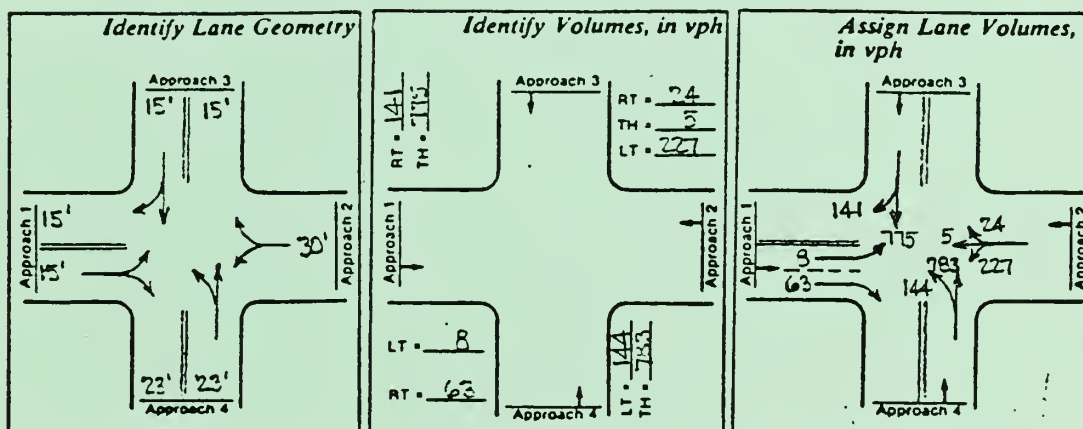
C:Rte. 9 WB Off-
1843
7.0
65
49
5
11
0.93
Y
Y
0

D:Rte. 9 On-ramp
1773
7.0
72
54
0
0
1.00
N
N
0
Very long delay
E

STEP 4 LEFT TURNS FROM
CONFLICTING FLOWS
CRITICAL GAPS
CAPACITY
ADJUST FOR IMP
SHARED LANE THRU
SHARED LANE RIGHT
DEMAND
SHARED LN DEMAND
CAPACITY OF SHARED LN
AVAILABLE RESERVE
DELAY
LOS

C:Rte. 9 WB Off-
1906
7.5
46
31
Y
Y
239
270
34
-236
Failure
E*

D:Rte. 9 On-ramp
1802
7.5
54
37
N
N
8
0
0
28
Very long delay
E



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES

P.M. Oct. '84

GENERAL CHARACTERISTICS

CONTROLS: STOP

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Rte 9 WB Off-r

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: Rte 9 On-ramp

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

VOLUMES

APPROACH	A: Winchester			B: Centre St.			C: Rte 9 WB Of			D: Rte 9 On-ra		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	182	1081	0	0	878	124	188	3	19	2	0	90
PERCENT GRADE	0.00			0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00			0.00	
PASSENGER CARS		97.00			99.00			97.00			99.00	
PERCENT LT TRU		1.00			0.00			1.00			0.00	
PERCENT HV TRU		2.00			1.00			2.00			1.00	
PASS CAR/HR	187			0			193	3	19	2	0	91

STEP 1 RIGHT TURNS FROM

C:Rte 9 WB Off-r

D:Rte 9 On-ramp

CONFLICTING FLOWS

1081

940

CRITICAL GAPS

6.0

6.0

CAPACITY

273

324

DEMAND

19

91

CAPACITY USED

7

28

IMPEDANCE FACTOR

0.96

0.79

SHARED LANE

Y

N

AVAILABLE RESERVE

0

233

DELAY

Average traffic dela

LOS

C

STEP 2 LEFT TURNS FROM

B:Centre St.

A:Winchester St.

CONFLICTING FLOWS

1081

1002

CRITICAL GAPS

5.0

5.0

CAPACITY

407

441

DEMAND

0

187

CAPACITY USED

0

42

IMPEDANCE FACTOR

1.00

0.65

AVAILABLE RESERVE

407

254

DELAY

Little or no delay

Average traffic dela

LOS

A

C

STEP 3 THRU MOVES FROM
 CONFLICTING FLOWS
 CRITICAL GAPS
 CAPACITY
 ADJUST FOR IMP
 DEMAND
 CAPACITY USED
 IMPEDANCE FACTOR
 SHARED LANE LEFT
 SHARED LANE RIGHT
 AVAILABLE RESERVE
 DELAY
 LOS

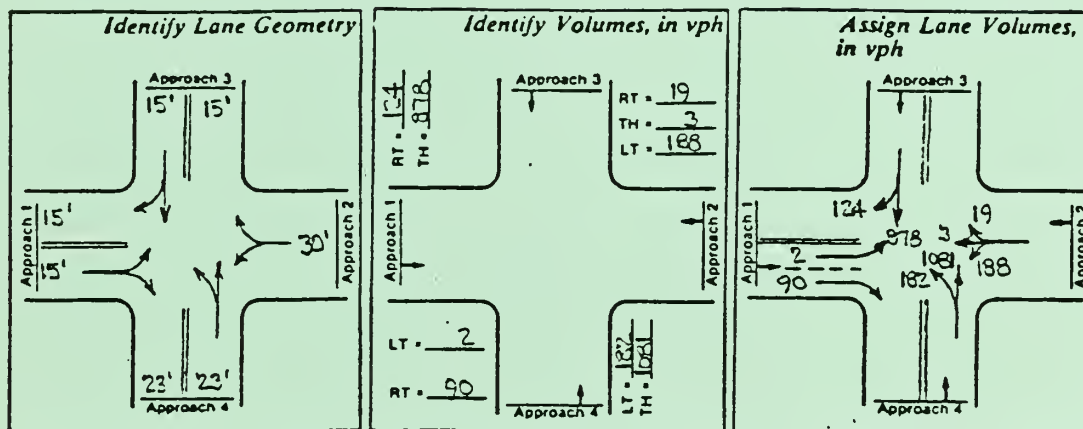
C:Rte 9 WB Off-r
 2265
 7.0
 36
 23
 3
 13
 0.92
 Y
 Y
 0

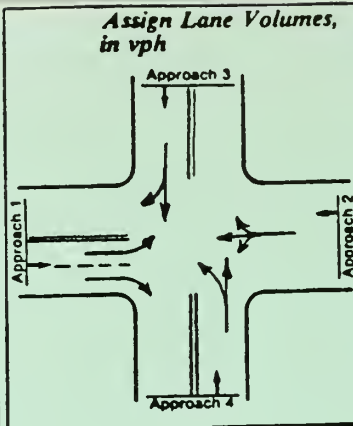
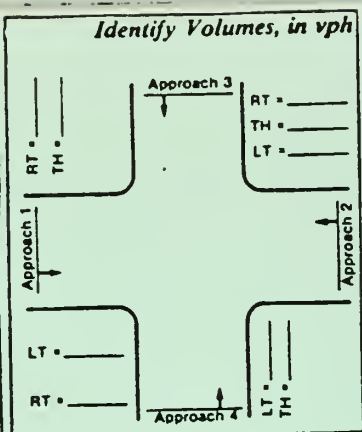
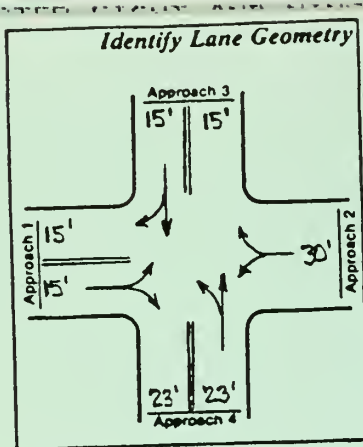
D:Rte 9 On-ramp
 2203
 7.0
 39
 26
 0
 0
 1.00
 N
 N
 0
 Very long delay
 E

STEP 4 LEFT TURNS FROM
 CONFLICTING FLOWS
 CRITICAL GAPS
 CAPACITY
 ADJUST FOR IMP
 SHARED LANE THRU
 SHARED LANE RIGHT
 DEMAND
 SHARED LN DEMAND
 CAPACITY OF SHARED LN
 AVAILABLE RESERVE
 DELAY
 LOS

C:Rte 9 WB Off-r
 2355
 7.5
 23
 12
 Y
 Y
 193
 215
 13
 -202
 Failure
 E*

D:Rte 9 On-ramp
 2225
 7.5
 28
 16
 N
 N
 2
 0
 0
 14
 Very long delay
 E





Central Street at
Rte 9 WB
on-off Ramp
Existing

CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

A.M. TOPICS

STEP ONE OUTPUT

	1	2	3	4
NAME	Winchstr EB	Centre St.	Rte 9 WBramp	Rte.9 Off ramp
#THRU LANES	1	1	1	1
AVG WIDTH	12	15	15	15
#LT LANES	1	0	0	0
AVG WIDTH	11	0	0	0
#RT LANES	0	0	0	1
AVG WIDTH	0	0	0	15

STEP TWO OUTPUT

	1	2	3	4
LT VOL	277	0	12	202
THRU VOL	1034	901	0	4
RT VOL	0	111	81	10
PED VOL	0	0	0	0
TRUCK %	3.7	2.3	4.3	6.5
BUS STOP	1	1	0	1

STEP FOUR OUTPUT

CYCLE (secs)	60	60	60	60
CHANGE INT	60	60	60	60
LT CAP ON CI	120	120	120	120
G/C	.83	.83	.16	.16
OP VOL	1012	1034	14	81
LT CAP ON GR	0	0	178	111
LT TOT CAP	120	120	298	231
LT VOL	277	0	12	202
PASS CHK	f	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.98	0.94	0.65	0.84
LT VOL	293	0	19	256
THRU VOL	1098	985	0	10
RT VOL	0	121	130	13

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	1012	1034	14	81
PCE LTU	6.00	6.00	1.00	1.00
PCE LTP	1.05	1.20	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B2	1758	308
A1	1098	1098
A211	1105	1105

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B2	1758	308
A1	1098	1098
A2B1	995	995
A3B4	134	138
A4B3	239	285

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

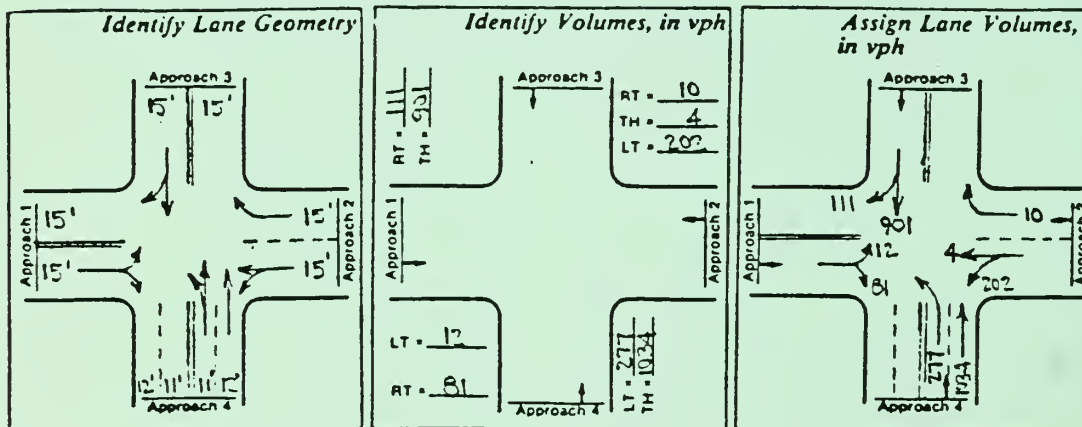
1758	1-one phase only
1405	2-two phase,one left protected,no overlap
1302	3-two phases,one left protected,overlap
2093	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

239	1-one phase only
423	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
Proposed → 3	1	0.90	1542	1720	E
2	1	0.96	1645	1720	E
3	8	1.05	1726	1650	F
2	8	1.11	1829	1650	F
1*	1	1.11	1997	1800	F
1*	8	1.27	2181	1720	F
8	1	1.36	2332	1720	F
8	8	1.52	2516	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN
MID TOPICS

STEP ONE OUTPUT

	1	2	3	4
NAME	Winchstr EB	Centre St.	Rte 9 WB ramp	Rte.9 Off ramp
#THRU LANES	1	1	1	1
AVG WIDTH	12	15	15	15
#LT LANES	1	0	0	0
AVG WIDTH	11	0	0	0
#RT LANES	0	0	0	1
AVG WIDTH	0	0	0	15

STEP TWO OUTPUT

	1	2	3	4
LT VOL	144	0	8	227
THRU VOL	1034	775	0	5
RT VOL	0	141	63	24
PED VOL	0	0	0	0
TRUCK %	5.6	3.6	2.8	6.6
BUS STOP	1	1	0	1

STEP FOUR OUTPUT

	1	2	3	4
CYCLE (secs)	60	60	60	60
CHANGE INT	60	60	60	60
LT CAP ON CI	120	120	120	120
G/C	.81	.81	.18	.18
OP VOL	916	1034	29	63
LT CAP ON GR	56	0	187	153
LT TOT CAP	176	120	307	273
LT VOL	144	0	8	227
PASS CHK	t	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.95	0.96	0.74	0.90
LT VOL	160	0	11	269
THRU VOL	1154	841	0	10
RT VOL	0	152	88	28

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	916	1034	29	63
PCE LTU	4.00	6.00	1.00	1.00
PCE LTP	1.05	1.20	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B2	640	168
A1	1154	1154
A2B1	993	993
A3B4	99	101
A4B3	279	333

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B2	640	168
A1	1154	1154
A2B1	893	893
A3B4	89	91
A4B3	251	300

STEP TEN OUTPUT

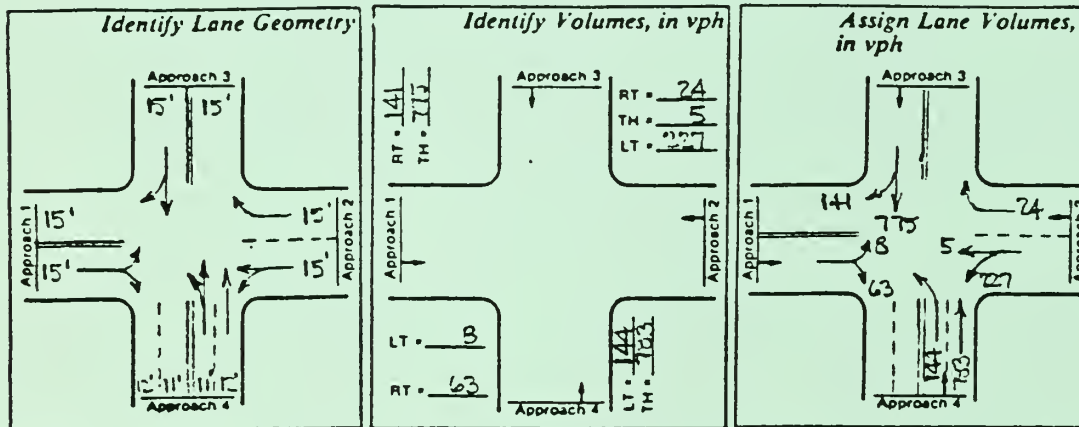
POSSIBLE PHASES APPROACHES 1 & 2

1154	1-one phase only
1322	2-two phase,one left protected,no overlap
1154	3-two phases,one left protected,overlap
2047	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

251	1-one phase only
391	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1	1	0.78	1405	1800	D
Proposed → 3	1	0.82	1405	1720	D
1	8	0.90	1544	1720	E
2	1	0.91	1573	1720	E
3	8	0.94	1544	1650	E
2	8	1.04	1712	1650	F
8	1	1.34	2299	1720	F
8	8	1.48	2438	1650	F



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

P.M. TOPICS

STEP ONE OUTPUT

	1	2	3	4
NAME	Winchstr EB	Centre St.	Rte 9 WB ramp	Rte.9 Off ramp
#THRU LANES	1	1	1	1
AVG WIDTH	12	15	15	15
#LT LANES	1	0	0	0
AVG WIDTH	11	0	0	0
#RT LANES	0	0	0	1
AVG WIDTH	0	0	0	15

STEP TWO OUTPUT

	1	2	3	4
LT VOL	182	0	2	188
THRU VOL	1081	878	0	3
RT VOL	0	124	90	19
PED VOL	0	0	0	0
TRUCK %	3.1	1.4	1.1	2.9
BUS STOP	1	1	0	1

STEP FOUR OUTPUT

CYCLE (secs)	60	60	60	60
CHANGE INT	60	60	60	60
LT CAP ON CI	120	120	120	120
G/C	.84	.84	.15	.15
OP VOL	1002	1081	22	90
LT CAP ON GR	6	0	158	90
LT TOT CAP	126	120	278	210
LT VOL	182	0	2	188
PASS CHK	f	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.91	0.92	0.72	0.86
LT VOL	206	0	3	225
THRU VOL	1229	972	0	8
RT VOL	0	137	126	23

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	1002	1081	22	90
PCE LTU	6.00	6.00	1.00	1.00
PCE LTP	1.05	1.20	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B2	1237	216
A1	1229	1229
A2B1	1109	1109
A3B4	129	130
A4B3	233	278

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B2	1237	216
A1	1229	1229
A2B1	998	998
A3B4	116	117
A4B3	210	250

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

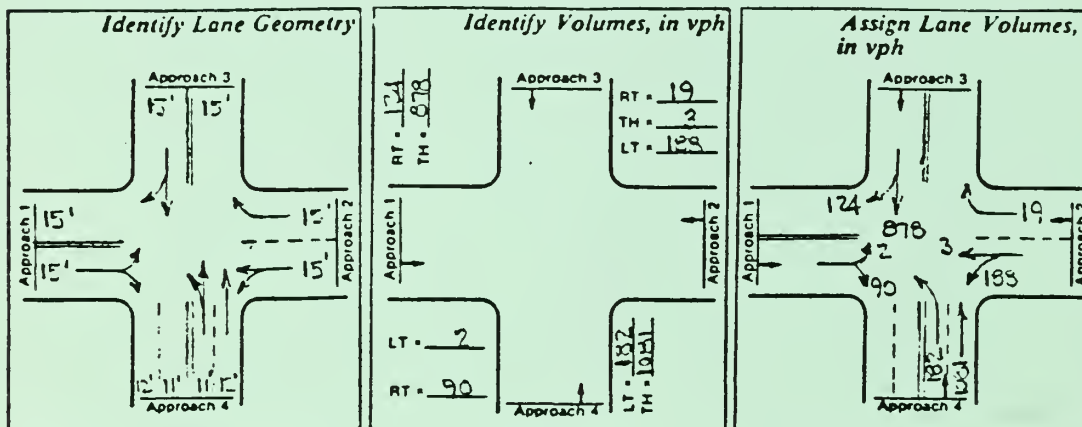
1237	1-one phase only
1446	2-two phase,one left protected,no overlap
1229	3-two phases,one left protected,overlap
2227	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

210	1-one phase only
367	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1*	1	0.80	1447	1800	D
Proposed → 3	1	0.84	1439	1720	D
1*	8	0.93	1604	1720	E
2	1	0.96	1655	1720	E
3	8	0.97	1596	1650	E
2	8	1.10	1913	1650	F
8	1	1.42	2437	1720	F
8	8	1.57	2594	1650	F

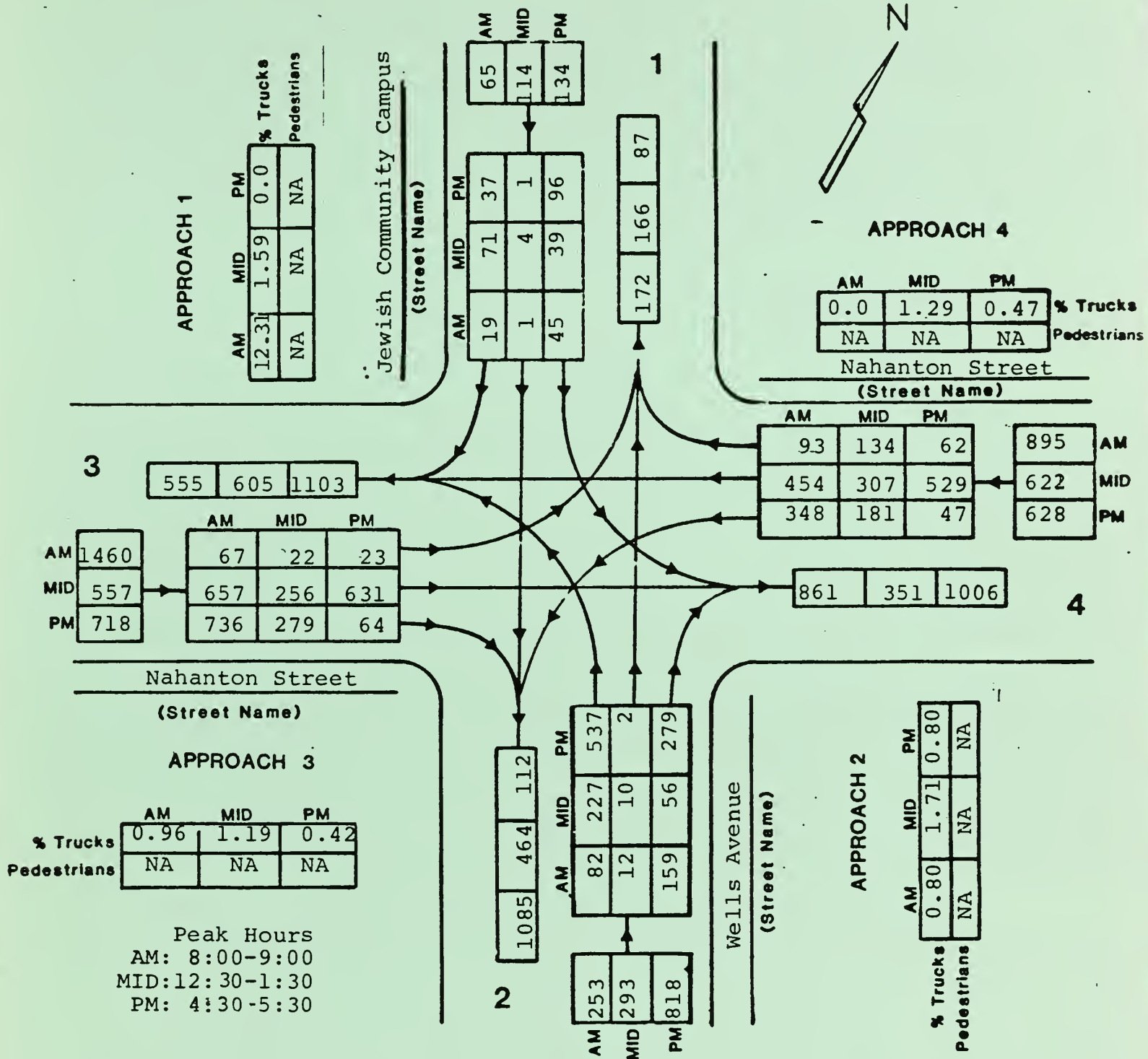
* This phasing may be inappropriate due to left turn restrictions see STEP FOUR OUTPUT above



SUMMARY OF VEHICLE MOVEMENTS

Intersection Nahanton Street @ Wells Avenue & the Jewish Community Campus

Date 9/19/84 Day of Week Wednesday Weather Fair 60°F Community Newton



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES

AM 9/84 ASSUME XLEFT ON WELLS AVE AND COMMUNITY CAMPUS RIGHT/DECEL ON NAHANTON ST EB

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Wells Ave.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: Community Camp

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: N

VOLUMES

APPROACH	A: Nahanton St			B: Nahanton St			C: Wells Ave.			D: Community C		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	67	657	0	348	454	93	82	12	159	45	1	19
PERCENT GRADE	0.00			0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00			0.00	
PASSENGER CARS		99.00			7100.00			99.00			88.00	
PERCENT LT TRU		0.00			0.00			0.00			6.00	
PERCENT HV TRU		1.00			0.00			1.00			6.00	
PASS CAR/HR	68			348			83	12	161	49	1	21

STEP 1 RIGHT TURNS FROM	C:Wells Ave.	D:Community Camp
CONFLICTING FLOWS	657	501
CRITICAL GAPS	5.0	5.0
CAPACITY	622	727
DEMAND	161	21
CAPACITY USED	26	3
IMPEDANCE FACTOR	0.81	0.99
SHARED LANE	Y	Y

STEP 2 LEFT TURNS FROM	B:Nahanton St.	A:Nahanton St.
CONFLICTING FLOWS	657	547
CRITICAL GAPS	5.0	5.0
CAPACITY	622	694
DEMAND	348	68
CAPACITY USED	56	10
IMPEDANCE FACTOR	0.51	0.94
AVAILABLE RESERVE	274	627
DELAY	Average traffic dela	Little or no delay
LOS	C	A

STEP 3 THRU MOVES FROM
 CONFLICTING FLOWS
 CRITICAL GAPS
 CAPACITY
 ADJUST FOR IMP
 DEMAND
 CAPACITY USED
 IMPEDANCE FACTOR
 SHARED LANE LEFT
 SHARED LANE RIGHT
 SHARED LN DEMAND
 CAPACITY OF SHARED LN
 AVAILABLE RESERVE
 DELAY
 LOS

C:Wells Ave.

1619
 6.0
 143
 69
 12
 17
 0.88
 N
 Y
 173
 399
 226
 C

D:Community Camp

1573
 6.0
 152
 73
 1
 1
 0.99
 N
 Y
 22
 503
 481
 A

Average traffic delaLittle or no delay

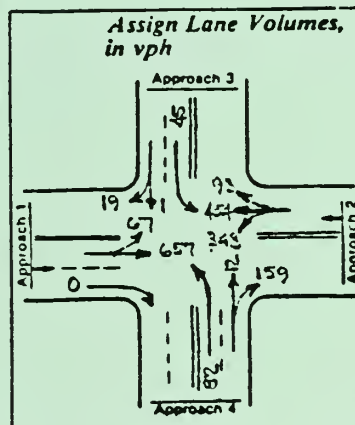
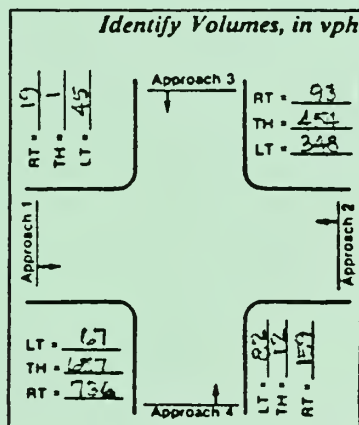
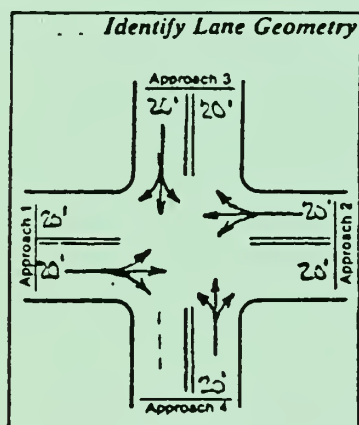
STEP 4 LEFT TURNS FROM
 CONFLICTING FLOWS
 CRITICAL GAPS
 CAPACITY
 ADJUST FOR IMP
 SHARED LANE THRU
 SHARED LANE RIGHT
 DEMAND
 SHARED LN DEMAND
 CAPACITY OF SHARED LN
 AVAILABLE RESERVE
 DELAY
 LOS

C:Wells Ave.

1639
 6.5
 110
 52
 N
 Y
 83
 0
 0
 -31
 Failure
 E*

D:Community Camp

1744
 6.5
 96
 33
 N
 Y
 49
 0
 0
 -16
 Failure
 E*



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES

MID 9/84 ASSUME XLEFT ON WELLS AVE AND COMMUNITY CAMPUS RIGHT DECEL ON NAHANTON N ST EB

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Wells Ave.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: Nahanton St.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: N

VOLUMES

APPROACH	A: Nahanton St			B: Nahanton St			C: Wells Ave.			D: Nahanton St		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	22	256	0	181	307	134	227	10	56	39	4	71
PERCENT GRADE	0.00			0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00			0.00	
PASSENGER CARS		99.00			99.00			98.00			98.00	
PERCENT LT TRU		0.00			0.00			1.00			1.00	
PERCENT HV TRU		1.00			1.00			1.00			1.00	
PASS CAR/HR	22			183			230	10	57	40	4	72

STEP 1 RIGHT TURNS FROM

CONFLICTING FLOWS

CRITICAL GAPS

CAPACITY

DEMAND

CAPACITY USED

IMPEDANCE FACTOR

SHARED LANE

C:Wells Ave.

256

5.0

929

57

6

0.97

Y

D:Nahanton St.

374

5.0

826

72

9

0.95

Y

STEP 2 LEFT TURNS FROM

CONFLICTING FLOWS

CRITICAL GAPS

CAPACITY

DEMAND

CAPACITY USED

IMPEDANCE FACTOR

AVAILABLE RESERVE

DELAY

LUS

B:Nahanton St.

256

5.0

929

183

20

0.86

746

Little or no delay

A

A:Nahanton St.

441

5.0

772

22

3

0.99

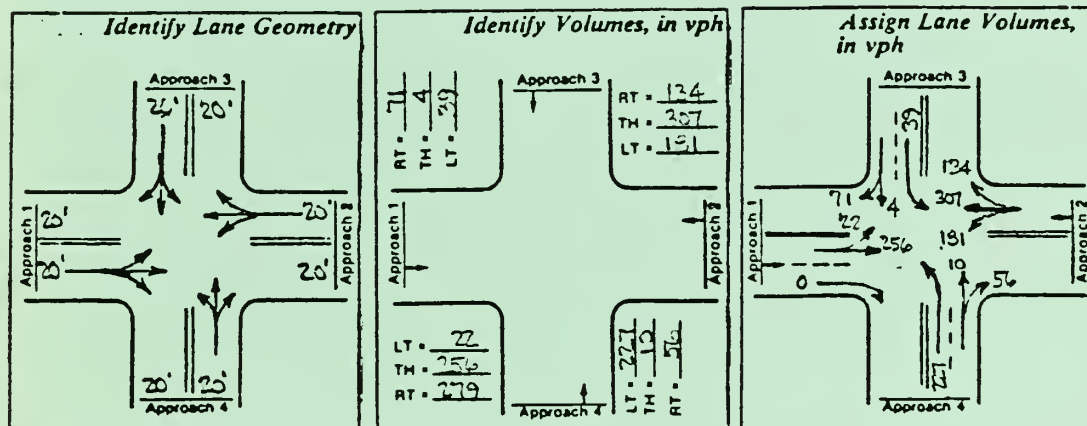
750

Little or no delay

A

	C:Wells Ave.	D:Nahanton St.
STEP 3 THRU MOVES FROM		
CONFLICTING FLOWS	900	833
CRITICAL GAPS	6.0	6.0
CAPACITY	340	368
ADJUST FOR IMP	289	313
DEMAND	10	4
CAPACITY USED	4	1
IMPEDANCE FACTOR	0.98	0.99
SHARED LANE LEFT	N	N
SHARED LANE RIGHT	Y	Y
SHARED LN DEMAND	67	76
CAPACITY OF SHARED LN	695	759
AVAILABLE RESERVE	628	683
DELAY	Little or no delay	Little or no delay
LOS	A	A

	C:Wells Ave.	D:Nahanton St.
STEP 4 LEFT TURNS FROM		
CONFLICTING FLOWS	975	899
CRITICAL GAPS	6.5	6.5
CAPACITY	260	287
ADJUST FOR IMP	208	232
SHARED LANE THRU	N	N
SHARED LANE RIGHT	Y	Y
DEMAND	230	40
SHARED LN DEMAND	0	0
CAPACITY OF SHARED LN	0	0
AVAILABLE RESERVE	-22	192
DELAY	Failure	Long traffic delay
LOS	E*	D



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 4 APPROACHES

PM 9/84 ASSUME XLEFT ON WELLS AVE AND COMMUNITY CAMPUS RIGHT/DECEL ON NAHANTON ST EB

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Wells Ave.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: N

APPROACH: D: Community Camp

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: N

VOLUMES

APPROACH	A: Nahanton St			B: Nahanton St			C: Wells Ave.			D: Community C		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	23	631	0	47	529	62	537	2	279	96	1	37
PERCENT GRADE	0.00			0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00			0.00	
PASSENGER CARS		%100.00			%100.00			99.00			%100.00	
PERCENT LT TRU		0.00			0.00			0.00			0.00	
PERCENT HV TRU		0.00			0.00			1.00			0.00	
PASS CAR/HR	23			47			542	2	282	96	1	37

STEP 1 RIGHT TURNS FROM	C: Wells Ave.	D: Community Camp
CONFLICTING FLOWS	631	560
CRITICAL GAPS	5.0	5.0
CAPACITY	638	685
DEMAND	282	37
CAPACITY USED	44	5
IMPEDANCE FACTOR	0.64	0.97
SHARED LANE	Y	Y

STEP 2 LEFT TURNS FROM	B: Nahanton St.	A: Nahanton St.
CONFLICTING FLOWS	631	591
CRITICAL GAPS	5.0	5.0
CAPACITY	638	665
DEMAND	47	23
CAPACITY USED	7	3
IMPEDANCE FACTOR	0.96	0.98
AVAILABLE RESERVE	591	642
DELAY	Little or no delay	Little or no delay
LOS	A	A

STEP 3 THRU MOVES FROM
 CONFLICTING FLOWS
 CRITICAL GAPS
 CAPACITY
 ADJUST FOR IMP
 DEMAND
 CAPACITY USED
 IMPEDANCE FACTOR
 SHARED LANE LEFT
 SHARED LANE RIGHT
 SHARED LN DEMAND
 CAPACITY OF SHARED LN
 AVAILABLE RESERVE
 DELAY
 LOS

C:Wells Ave.

1292
 6.0
 212
 200
 2
 1
 1.00
 N
 Y
 284
 629
 345
 Short traffic delay Little or no delay
 B

D:Community Camp

1261
 6.0
 220
 207
 1
 0
 1.00
 N
 Y
 38
 646
 608
 A

STEP 4 LEFT TURNS FROM
 CONFLICTING FLOWS
 CRITICAL GAPS
 CAPACITY
 ADJUST FOR IMP
 SHARED LANE THRU
 SHARED LANE RIGHT
 DEMAND
 SHARED LN DEMAND
 CAPACITY OF SHARED LN
 AVAILABLE RESERVE
 DELAY
 LOS

C:Wells Ave.

1330
 6.5
 164
 150
 N
 Y
 542
 0
 0
 -393
 Failure

D:Community Camp

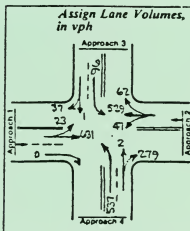
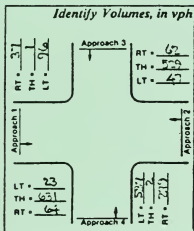
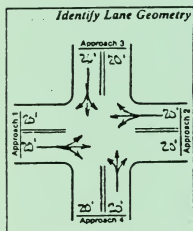
1542
 6.5
 124
 74
 N
 Y
 96
 0
 0
 -22
 Failure

Failure

Failure

E*

E*



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

A.M. Install Signals & X Left on Nahanton WB X Right on Nahanton ^{EB} ~~WB~~ (Effects Nahanton right turns into Wells Ave. reduced by 30%).

STEP ONE OUTPUT

	1	2	3	4
NAME	Nahanton St.	Nahanton St.	mmunity Campus	Wells Ave.
#THRU LANES	1	1	2	2
AVG WIDTH	10	10	9	8
#LT LANES	0	1	0	0
AVG WIDTH	0	10	0	0
#RT LANES	1	0	0	0
AVG WIDTH	10	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	67	348	45	82
THRU VOL	657	454	1	12
RT VOL	515	93	19	159
PED VOL	0	0	0	0
TRUCK %	1.0	0.0	12.3	0.8
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE (secs)	60	60	60	60
CHANGE INT	60	60	60	60
LT CAP ON C1	120	120	120	120
G/C	.85	.85	.14	.14
OP VOL	547	1172	171	20
LT CAP ON GR	473	0	0	148
LT TOT CAP	593	120	120	268
LT VOL	67	348	45	82
PASS CHK	t	f	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.80	0.72	0.86	0.80
LT VOL	85	483	59	103
THRU VOL	829	631	1	15
RT VOL	650	129	25	200

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	547	1172	171	20
PCE LTU	2.00	6.00	1.00	1.00
PCE LTP	1.20	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B1	2900	507
A2	760	760
A1B2	998	931
A2B1	1921	703
A3B4	85	97
A4B3	319	339

factS STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B1	2900	507
A2	760	760
A1B2	998	931
A2B1	1921	703
A3B4	49	56
A4B3	184	196

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

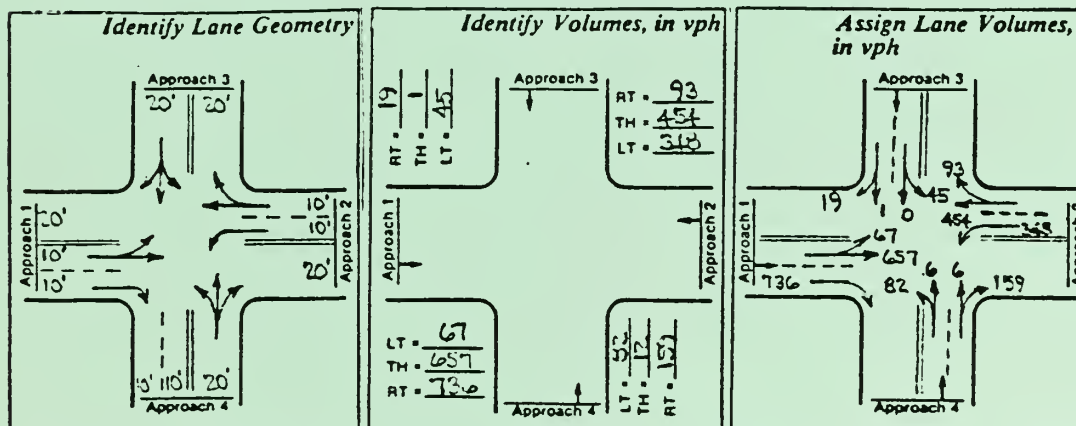
2900	1-one phase only
1506	2-two phase,one left protected,no overlap
1506	3-two phases,one left protected,overlap
1690	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

184	1-one phase only
252	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
2	1	0.98	1690	1720	E
3	1	0.98	1690	1720	E
2	8	1.07	1758	1650	F
3	8	1.07	1758	1650	F
8	1	1.09	1874	1720	F
8	8	1.18	1942	1650	F
1*	1	1.71	3084	1800	F
1*	8	1.83	3152	1720	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

MID Install signal & Xleft on Nahanton WB Xright on Nahanton EB (Effects of r
ht turn from Nahanton to Wells Ave. reduced by 30%).

STEP ONE OUTPUT

	1	2	3	4
NAME	Nahanton St.	Nahanton St.	mmunity Campus	Wells Ave.
#THRU LANES	1	1	2	2
AVG WIDTH	10	10	9	8
#LT LANES	0	1	0	0
AVG WIDTH	0	10	0	0
#RT LANES	1	0	0	0
AVG WIDTH	10	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	22	134	39	227
THRU VOL	256	307	4	10
RT VOL	195	181	71	56
PED VOL	0	0	0	0
TRUCK %	1.2	1.3	1.6	1.7
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

CYCLE(secs)	60	60	60	60
CHANGE INT	60	60	60	60
LT CAP ON CI	120	120	120	120
G/C	.76	.76	.23	.23
OP VOL	488	451	66	75
LT CAP ON GR	424	461	210	201
LT TOT CAP	544	581	330	321
LT VOL	22	134	39	227
PASS CHK	t	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.80	0.79	0.66	0.84
LT VOL	28	172	60	275
THRU VOL	324	394	6	12
RT VOL	247	232	109	68

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	488	451	66	75
PCE LTU	2.00	2.00	1.00	1.00
PCE LTP	1.20	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B1	344	180
A2	626	626
A1B2	379	357
A3B4	175	187
A4B3	355	410

STEP EIGHT AND NINE A OUTPUT

UNPROTECT LT PROTECT LT

B1	344	180
A2	626	626
A1B2	379	357
A3B4	101	108
A4B3	205	237

STEP TEN OUTPUT

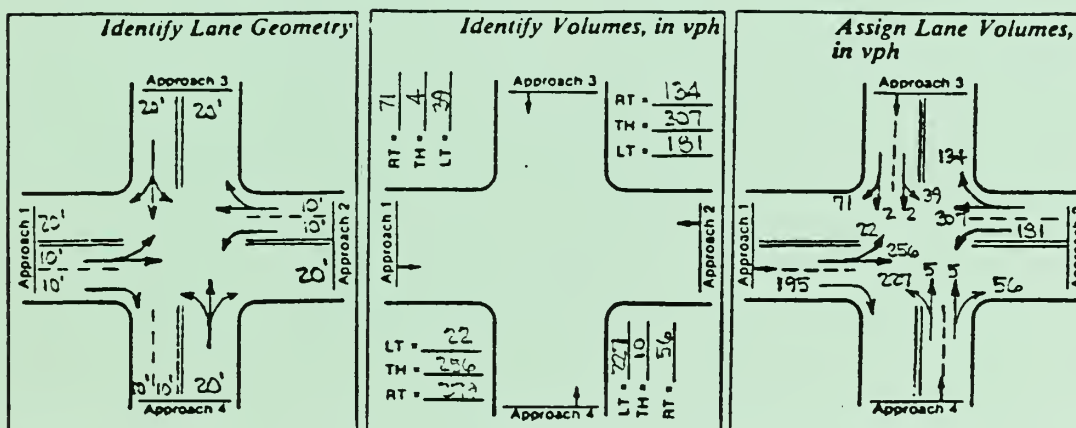
POSSIBLE PHASES APPROACHES 1 & 2

626	1-one phase only
806	2-two phase,one left protected,no overlap
626	3-two phases,one left protected,overlap
983	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

205	1-one phase only
345	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LDS
1	1	0.46	831	1800	A
3	1	0.48	831	1720	A
1	8	0.56	971	1720	B
2	1	0.59	1011	1720	B
3	8	0.59	971	1650	B
8	1	0.69	1188	1720	C
2	8	0.70	1151	1650	C
8	8	0.80	1328	1650	D



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

PM Install signal & X left on Nahnton WB X right on Nahanton EB (Effects of rht turns from Nahanton to Wells Ave. reduced by 30%).

STEP ONE OUTPUT

	1	2	3	4
NAME	Nahanton St.	Nahanton St. community Campus		Wells Ave.
#THRU LANES	1	1	2	2
AVG WIDTH	10	10	9	8
#LT LANES	0	1	0	0
AVG WIDTH	0	10	0	0
#RT LANES	1	0	0	0
AVG WIDTH	10	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	23	47	96	537
THRU VOL	631	529	1	2
RT VOL	45	62	37	279
PED VOL	0	0	0	0
TRUCK %	0.4	0.5	0.0	0.8
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

CYCLE(secs)	60	60	60	60
CHANGE INT	60	60	60	60
LT CAP ON C1	120	120	120	120
G/C	.61	.61	.38	.38
OP VOL	591	676	281	38
LT CAP ON GR	141	56	175	418
LT TOT CAP	261	176	295	538
LT VOL	23	47	96	537
PASS CHK	t	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.86	0.88	0.74	0.80
LT VOL	27	54	130	677
THRU VOL	737	604	1	3
RT VOL	53	71	50	352

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	591	676	281	38
PCE LTU	2.00	4.00	1.00	1.00
PCE LTP	1.20	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B1	215	56
A2	675	675
A1B2	790	769
A3B4	181	207
A4B5	1001	1166

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B1	215	56
A2	675	675
A1B2	790	769
A3B4	105	120
A4B3	595	673

STEP TEN OUTPUT

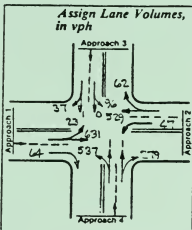
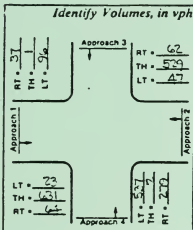
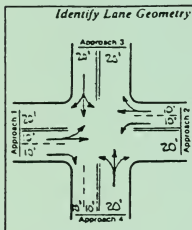
POSSIBLE PHASES APPROACHES 1 & 2

790	1-one phase only
847	2-two phase,one left protected,no overlap
847	3-two phases,one left protected,overlap
1444	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

595	1-one phase only
793	8-two phases,directional split

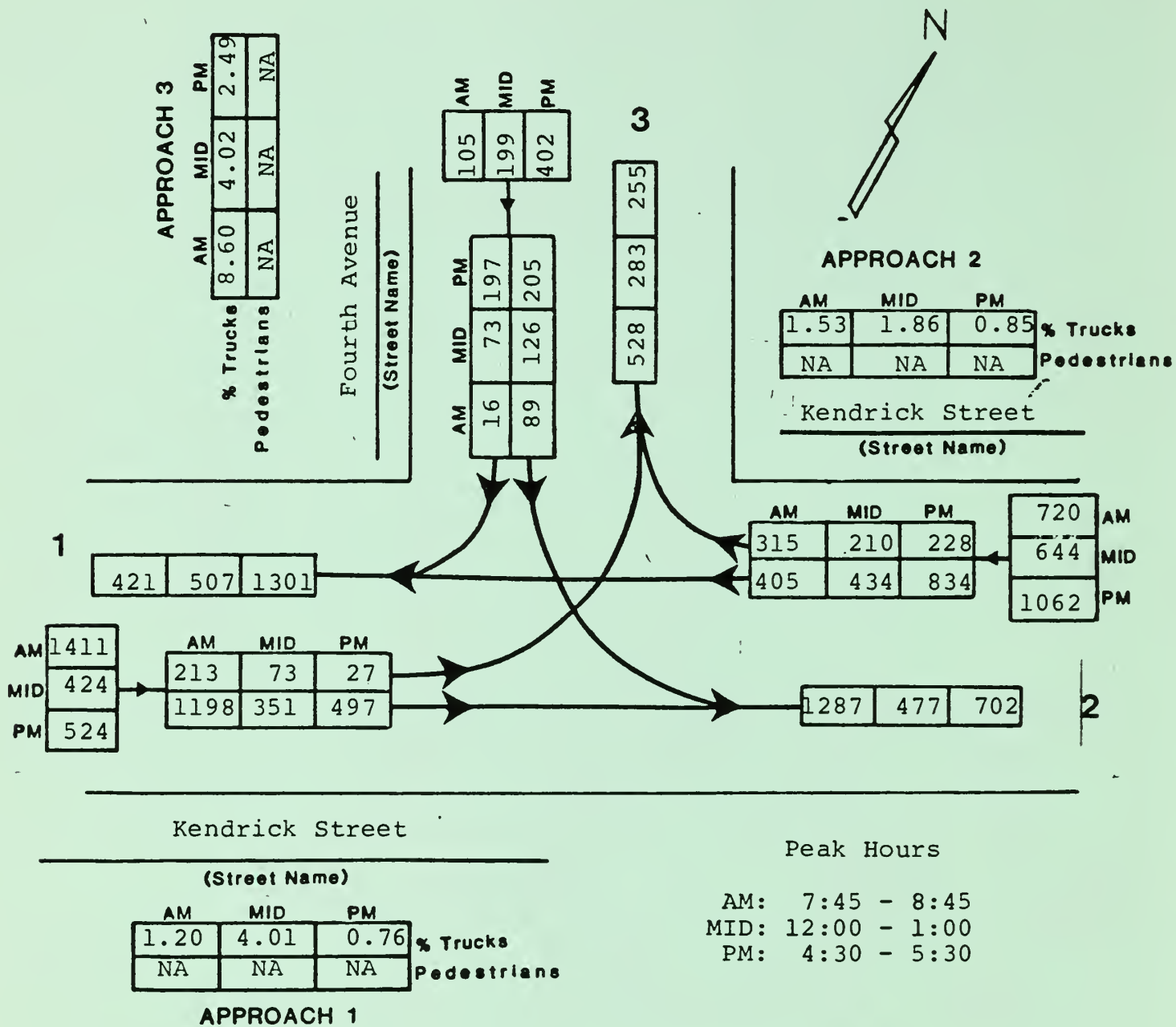
Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1	1	0.77	1386	1800	C
2	1	0.84	1442	1720	D
3	1	0.84	1442	1720	D
1	8	0.92	1583	1720	E
3	8	0.99	1640	1650	E
2	8	0.99	1640	1650	E
8	1	1.19	2039	1720	F
8	8	1.36	2237	1650	F



SUMMARY OF VEHICLE MOVEMENTS

Intersection Kendrick Street @ Fourth Avenue

Date 9/20/84 Day of Week Thursday Weather Fair 60°F Community Needham



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

● A.M. w/ right decel & Xleft/right

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

● MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Fourth Ave.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

VOLUMES

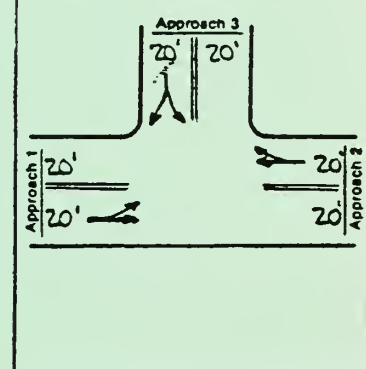
APPROACH	A: Kendrick St			B: Kendrick St			C: Fourth Ave.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
● VOLUME	0	405	0	213	1198	0	89	0	16
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00	
PASSENGER CARS		98.00			99.00			91.00	
PERCENT LT TRU		1.00			0.00			4.00	
PERCENT HV TRU		1.00			1.00			5.00	
● PASS CAR/HR	0			215			95	0	17

STEP 1 RIGHT TURNS FROM	C:Fourth Ave.
CONFLICTING FLOWS	405
CRITICAL GAPS	5.0
● CAPACITY	800
DEMAND	17
SHARED LANE	N
AVAILABLE RESERVE	783
DELAY	Little or no delay
LOS	A

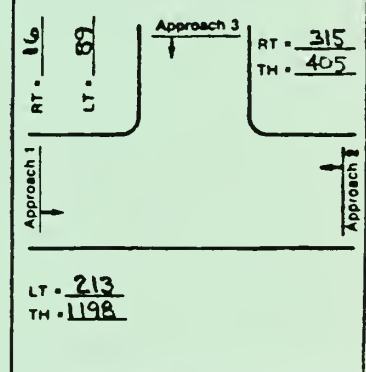
STEP 2 LEFT TURNS FROM	B:Kendrick St.
CONFLICTING FLOWS	405
CRITICAL GAPS	5.0
CAPACITY	800
● DEMAND	215
CAPACITY USED	27
IMPEDANCE FACTOR	0.80
AVAILABLE RESERVE	585
DELAY	Little or no delay
LOS	A

STEP 3 LEFT TURNS FROM	C:Fourth Ave.
CONFLICTING FLOWS	1816
CRITICAL GAPS	6.5
CAPACITY	87
● ADJUST FOR IMP	70
SHARED LANE THRU	N
SHARED LANE RIGHT	N
DEMAND	95
AVAILABLE RESERVE	-26
DELAY	Failure
● LOS	E*

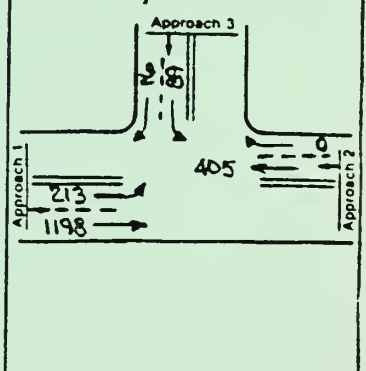
Identify Lane Geometry



Identify Volumes, in vph



Assign Lane Volumes, in vph



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

MID w/right decel & Xleft/ right lanes

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Fourth Ave.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

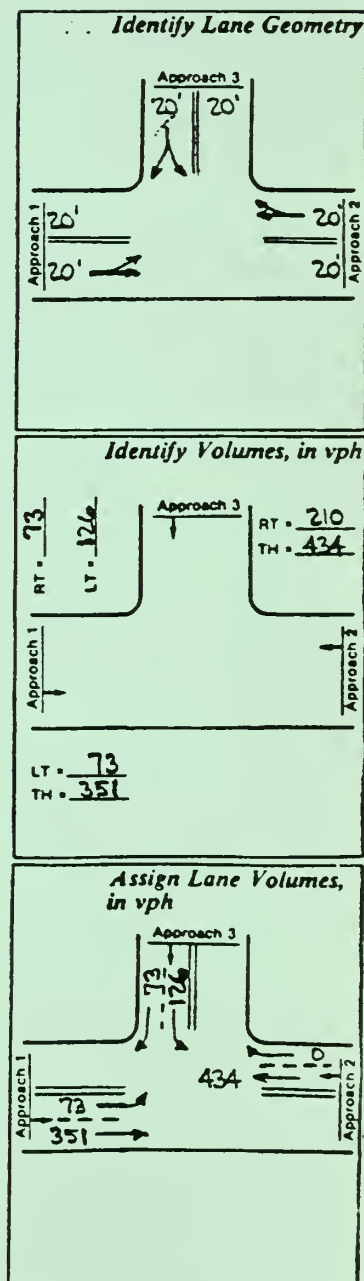
VOLUMES

APPROACH	A: Kendrick St			B: Kendrick St			C: Fourth Ave.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	434	0	73	351	0	126	0	73
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES	0.00			0.00			0.00		
PASSENGER CARS	98.00			96.00			96.00		
PERCENT LT TRU	1.00			2.00			2.00		
PERCENT HV TRU	1.00			2.00			2.00		
PASS CAR/HR	0			75			130	0	75

STEP 1 RIGHT TURNS FROM	C:Fourth Ave.
CONFLICTING FLOWS	434
CRITICAL GAPS	5.0
CAPACITY	777
DEMAND	75
SHARED LANE	N
AVAILABLE RESERVE	702
DELAY	Little or no delay
LOS	A

STEP 2 LEFT TURNS FROM	B:Kendrick St.
CONFLICTING FLOWS	434
CRITICAL GAPS	5.0
CAPACITY	777
DEMAND	75
CAPACITY USED	10
IMPEDANCE FACTOR	0.94
AVAILABLE RESERVE	702
DELAY	Little or no delay
LOS	A

STEP 3 LEFT TURNS FROM	C:Fourth Ave.
CONFLICTING FLOWS	858
CRITICAL GAPS	6.5
CAPACITY	303
ADJUST FOR IMP	285
SHARED LANE THRU	N
SHARED LANE RIGHT	N
DEMAND	130
AVAILABLE RESERVE	155
DELAY	Long traffic delay
LOS	D



P.M. Right decel w/ Xleft & right lanes

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Fourth Ave.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

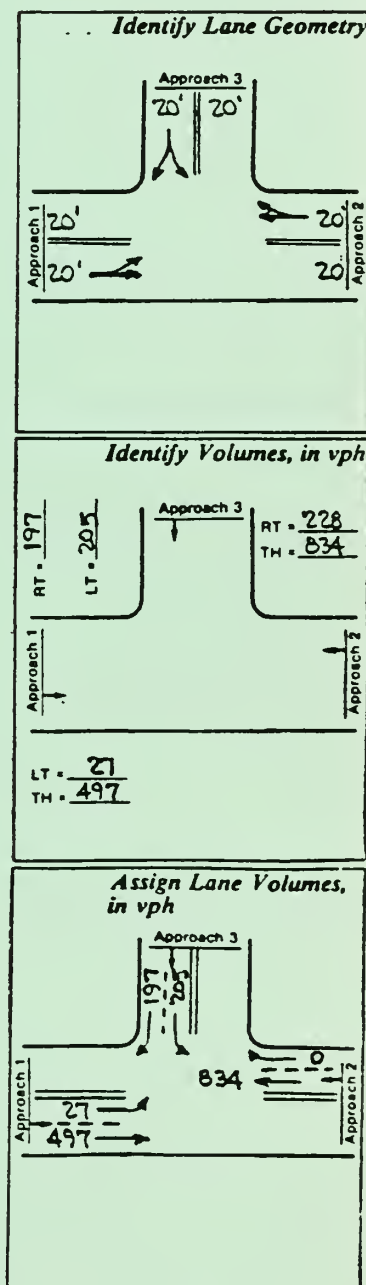
VOLUMES

APPROACH	A: Kendrick St			B: Kendrick St			C: Fourth Ave.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	834	0	27	497	0	205	0	197
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES	0.00			0.00			0.00		
PASSENGER CARS	99.00			98.00			98.00		
PERCENT LT TRU	0.00			1.00			1.00		
PERCENT HV TRU	1.00			1.00			1.00		
PASS CAR/HR	0			27			208	0	200

STEP 1 RIGHT TURNS FROM	C:Fourth Ave.
CONFLICTING FLOWS	834
CRITICAL GAPS	5.0
CAPACITY	521
DEMAND	200
SHARED LANE	N
AVAILABLE RESERVE	321
DELAY	Short traffic delay
LOS	B

STEP 2 LEFT TURNS FROM	B:Kendrick St.
CONFLICTING FLOWS	834
CRITICAL GAPS	5.0
CAPACITY	521
DEMAND	27
CAPACITY USED	5
IMPEDANCE FACTOR	0.97
AVAILABLE RESERVE	494
DELAY	Little or no delay
LOS	A

STEP 3 LEFT TURNS FROM	C:Fourth Ave.
CONFLICTING FLOWS	1358
CRITICAL GAPS	6.5
CAPACITY	158
ADJUST FOR IMP	154
SHARED LANE THRU	N
SHARED LANE RIGHT	N
DEMAND	208
AVAILABLE RESERVE	-55
DELAY	Failure
LOS	E*



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

AM ONE-WAY INBOUND SIGNAL AT THIRD AVE FOR OUTBOUND MOVEMENTS

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Fourth Ave.

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

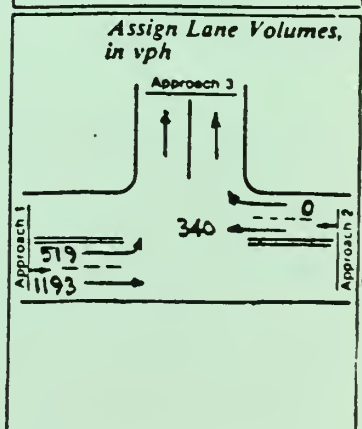
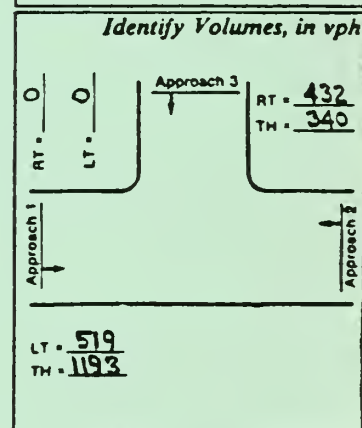
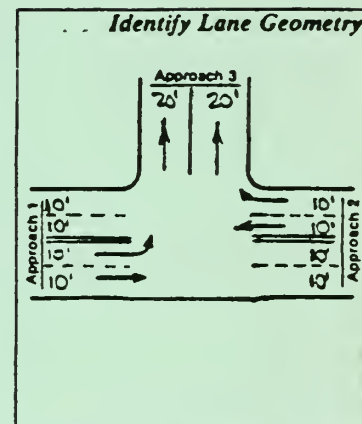
VOLUMES

APPROACH	A: Kendrick St			B: Kendrick St			C: Fourth Ave.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	340	0	519	1193	0	0	0	0
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES	0.00			0.00			%100.00		
PASSENGER CARS	99.00			99.00			0.00		
PERCENT LT TRU	0.00			0.00			0.00		
PERCENT HV TRU	1.00			1.00			0.00		
PASS CAR/HR	0			524			0	0	0

STEP 1 RIGHT TURNS FROM C:Fourth Ave.
 CONFLICTING FLOWS 340
 CRITICAL GAPS 5.0
 CAPACITY 854
 SHARED LANE Y

STEP 2 LEFT TURNS FROM B:Kendrick St.
 CONFLICTING FLOWS 340
 CRITICAL GAPS 5.0
 CAPACITY 854
 DEMAND 524
 CAPACITY USED 61
 IMPEDANCE FACTOR 0.46
 AVAILABLE RESERVE 330
 DELAY Short traffic delay
 LOS B

STEP 3 LEFT TURNS FROM C:Fourth Ave.
 CONFLICTING FLOWS 2052
 CRITICAL GAPS 6.5
 CAPACITY 64
 ADJUST FOR IMP 29
 SHARED LANE THRU Y
 SHARED LANE RIGHT Y
 SHARED LN DEMAND 0
 CAPACITY OF SHARED LN % 1.701412E+38
 AVAILABLE RESERVE % 1.701412E+38
 DELAY Little or no delay
 LOS A



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

1) MID ONE-WAY INBOUND SIGNAL AT THIRD AVE FOR OUTBOUND MOVEMENTS

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

2) MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Fourth Ave.

EXCLUSIVE LEFT TURN LANES: N

3) EXCLUSIVE RIGHT TURN LANES: N

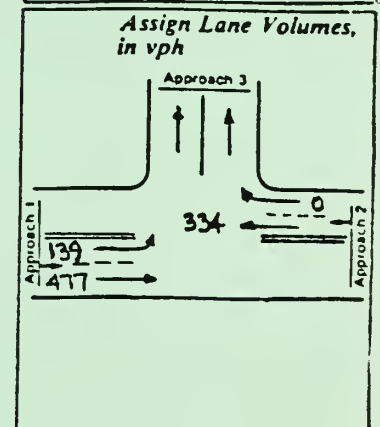
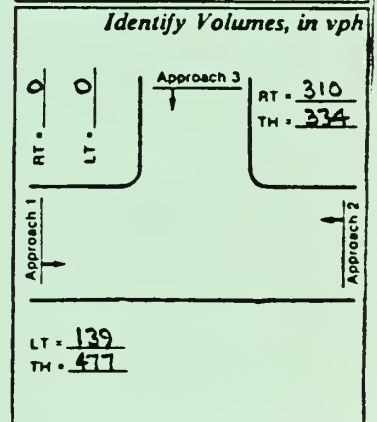
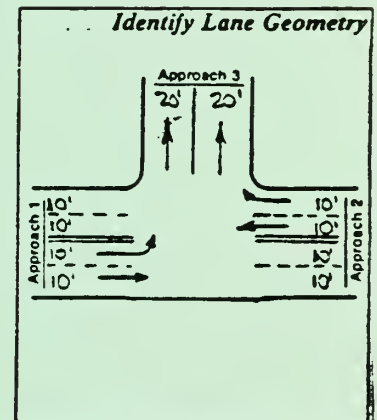
VOLUMES

APPROACH	A: Kendrick St			B: Kendrick St			C: Fourth Ave.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	334	0	139	477	0	0	0	0
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00	
PASSENGER CARS		98.00			96.00			0.00	
PERCENT LT TRU		1.00			2.00			0.00	
PERCENT HV TRU		1.00			2.00			0.00	
PASS CAR/HR	0			143			0	0	0

STEP 1 RIGHT TURNS FROM	C:Fourth Ave.
CONFLICTING FLOWS	334
CRITICAL GAPS	5.0
CAPACITY	859
SHARED LANE	Y

STEP 2 LEFT TURNS FROM	B:Kendrick St.
CONFLICTING FLOWS	334
CRITICAL GAPS	5.0
CAPACITY	859
DEMAND	143
CAPACITY USED	17
IMPEDANCE FACTOR	0.89
AVAILABLE RESERVE	716
DELAY	Little or no delay
LOS	A

STEP 3 LEFT TURNS FROM	C:Fourth Ave.
CONFLICTING FLOWS	950
CRITICAL GAPS	6.5
CAPACITY	268
ADJUST FOR IMP	238
SHARED LANE THRU	Y
SHARED LANE RIGHT	Y
SHARED LN DEMAND	0
CAPACITY OF SHARED LN	% 1.701412E+38
AVAILABLE RESERVE	% 1.701412E+38
DELAY	Little or no delay
LOS	A



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

PM ONE-WAY INBOUND SIGNAL AT THIRD AVE FOR OUTBOUND MOVEMENTS

GENERAL CHARACTERISTICS

CONTROLS: YIELD
PREVAILING SPEED: 30 MPH
MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Fourth Ave.
EXCLUSIVE LEFT TURN LANES: N
EXCLUSIVE RIGHT TURN LANES: N

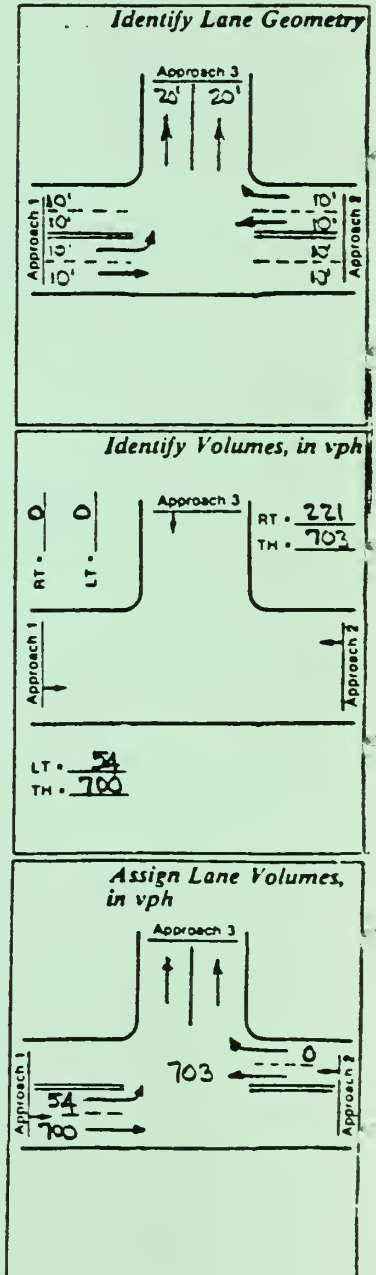
VOLUMES

APPROACH	A: Kendrick St			B: Kendrick St			C: Fourth Ave.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	703	0	54	700	0	0	0	0
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00	
PASSENGER CARS		98.00			99.00			0.00	
PERCENT LT TRU		1.00			0.00			0.00	
PERCENT HV TRU		1.00			1.00			0.00	
PASS CAR/HR	0			55			0	0	0

STEP 1 RIGHT TURNS FROM C:Fourth Ave.
CONFLICTING FLOWS 703
CRITICAL GAPS 5.0
CAPACITY 594
SHARED LANE Y

STEP 2 LEFT TURNS FROM B:Kendrick St.
CONFLICTING FLOWS 703
CRITICAL GAPS 5.0
CAPACITY 594
DEMAND 55
CAPACITY USED 9
IMPEDANCE FACTOR 0.95
AVAILABLE RESERVE 540
DELAY Little or no delay
LOS A

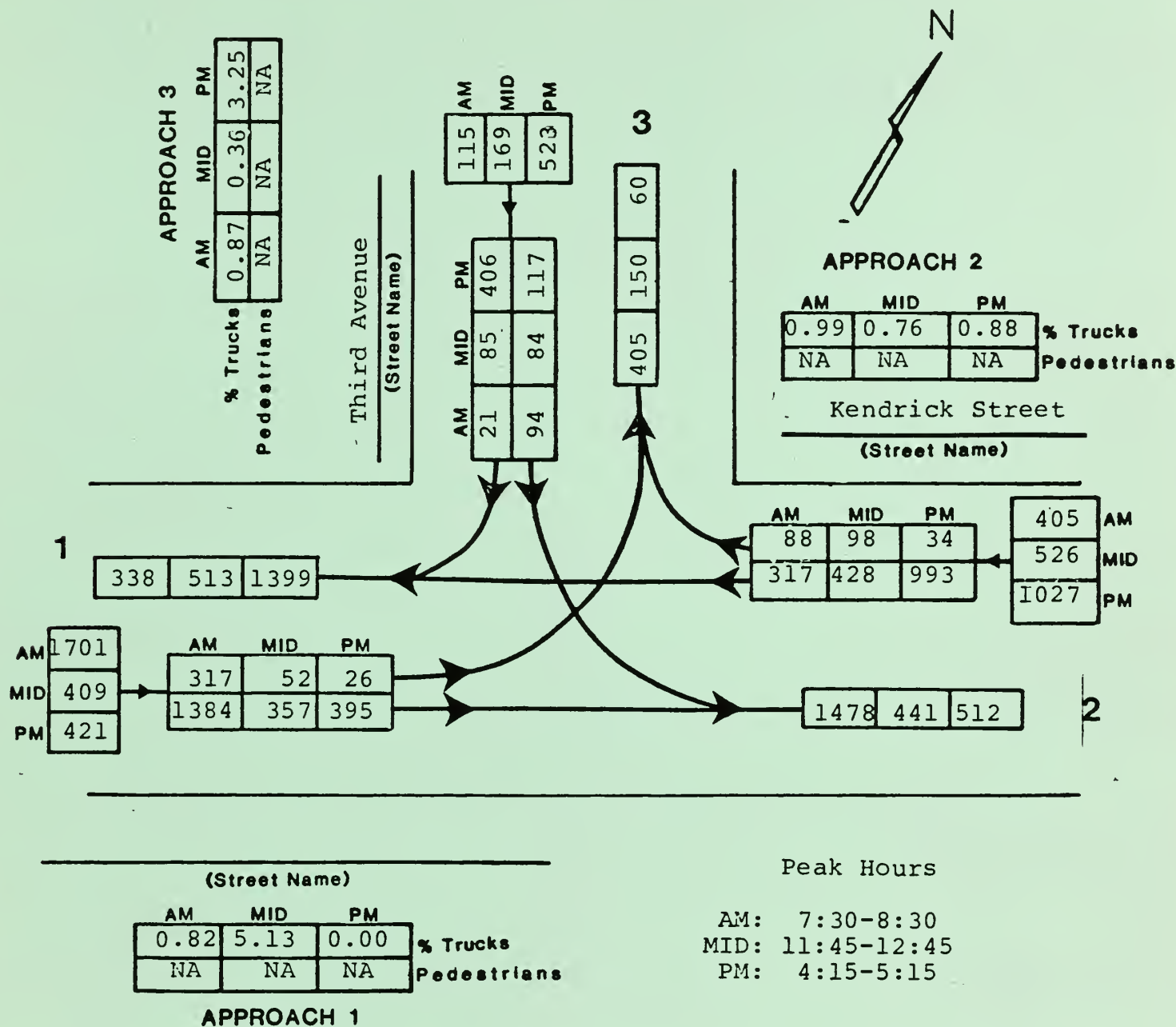
STEP 3 LEFT TURNS FROM C:Fourth Ave.
CONFLICTING FLOWS 1457
CRITICAL GAPS 6.5
CAPACITY 139
ADJUST FOR IMP 131
SHARED LANE THRU Y
SHARED LANE RIGHT Y
SHARED LN DEMAND 0
CAPACITY OF SHARED LN % 1.701412E+38
AVAILABLE RESERVE % 1.701412E+38
DELAY Little or no delay
LOS A



SUMMARY OF VEHICLE MOVEMENTS

Intersection Kendrick Street @ Third Avenue

Date 9/20/84 Day of Week Thursday Weather Fair 60°F Community Needham



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

A.M. right decel w/Xleft & right lanes

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Third Ave.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

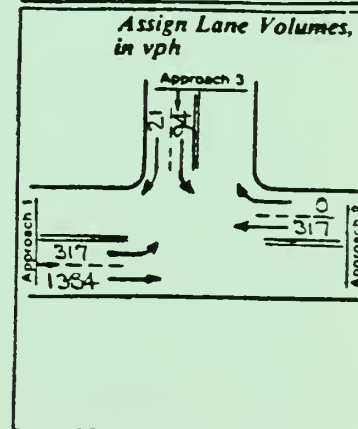
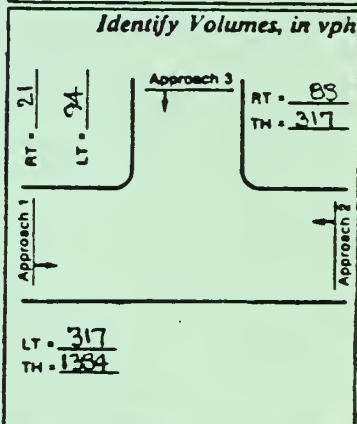
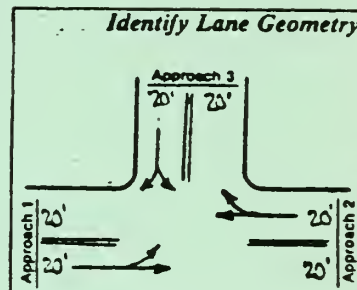
VOLUMES

APPROACH	A: Kendrick St			B: Kendrick St			C: Third Ave.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	317	0	317	1384	0	94	0	21
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00	
PASSENGER CARS		99.00			99.00			99.00	
PERCENT LT TRU		0.00			0.00			0.00	
PERCENT HV TRU		1.00			1.00			1.00	
PASS CAR/HR	0			320			95	0	21

STEP 1 RIGHT TURNS FROM	C:Third Ave.
CONFLICTING FLOWS	317
CRITICAL GAPS	5.0
CAPACITY	874
DEMAND	21
SHARED LANE	N
AVAILABLE RESERVE	853
DELAY	Little or no delay
LOS	A

STEP 2 LEFT TURNS FROM	B:Kendrick St.
CONFLICTING FLOWS	317
CRITICAL GAPS	5.0
CAPACITY	874
DEMAND	320
CAPACITY USED	37
IMPEDANCE FACTOR	0.71
AVAILABLE RESERVE	554
DELAY	Little or no delay
LOS	A

STEP 3 LEFT TURNS FROM	C:Third Ave.
CONFLICTING FLOWS	2018
CRITICAL GAPS	6.5
CAPACITY	67
ADJUST FOR IMP	47
SHARED LANE THRU	N
SHARED LANE RIGHT	N
DEMAND	95
AVAILABLE RESERVE	-47
DELAY	Failure
LOS	E*



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

● MID right decel w/left & right lanes

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

● MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Third Ave.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

VOLUMES

APPROACH	A: Kendrick St			B: Kendrick St			C: Third Ave.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
● VOLUME	0	428	0	52	357	0	84	0	85
PERCENT GRADE	0.00		0.00			0.00			
PERCENT CYCLES		0.00			0.00			0.00	
PASSENGER CARS		99.00			95.00			100.00	
PERCENT LT TRU		0.00			2.00			0.00	
PERCENT HV TRU		1.00			3.00			0.00	
● PASS CAR/HR	0			54			84	0	85

STEP 1 RIGHT TURNS FROM

C: Third Ave.

CONFLICTING FLOWS	428
CRITICAL GAPS	5.0
● CAPACITY	782
DEMAND	85
SHARED LANE	N
AVAILABLE RESERVE	697
DELAY	Little or no delay
LOS	A

STEP 2 LEFT TURNS FROM

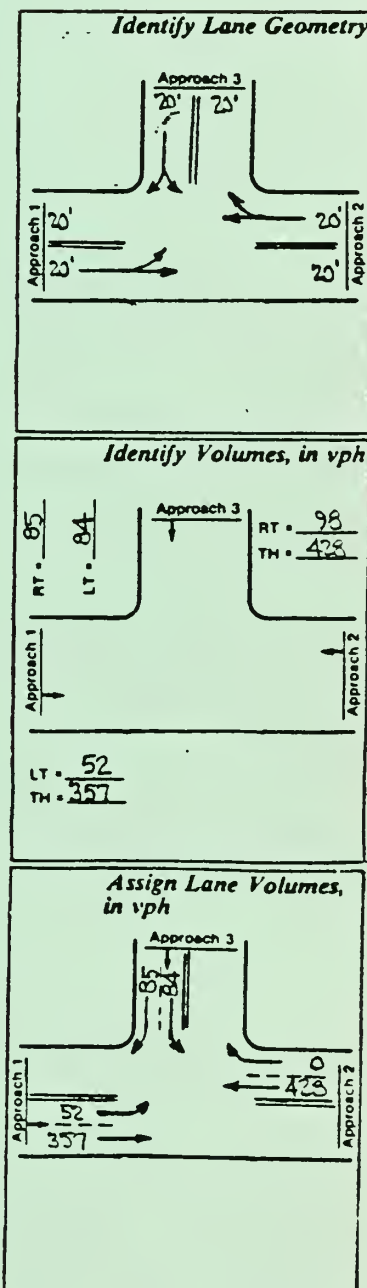
B: Kendrick St.

CONFLICTING FLOWS	428
CRITICAL GAPS	5.0
CAPACITY	782
● DEMAND	54
CAPACITY USED	7
IMPEDANCE FACTOR	0.96
AVAILABLE RESERVE	728
DELAY	Little or no delay
LOS	A

STEP 3 LEFT TURNS FROM

C: Third Ave.

CONFLICTING FLOWS	837
CRITICAL GAPS	6.5
CAPACITY	311
● ADJUST FOR IMP	299
SHARED LANE THRU	N
SHARED LANE RIGHT	N
DEMAND	84
AVAILABLE RESERVE	215
DELAY	Average traffic dela
● LOS	C



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

P.M. right decel w/left &right lanes

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Third Ave.

EXCLUSIVE LEFT TURN LANES: Y

EXCLUSIVE RIGHT TURN LANES: Y

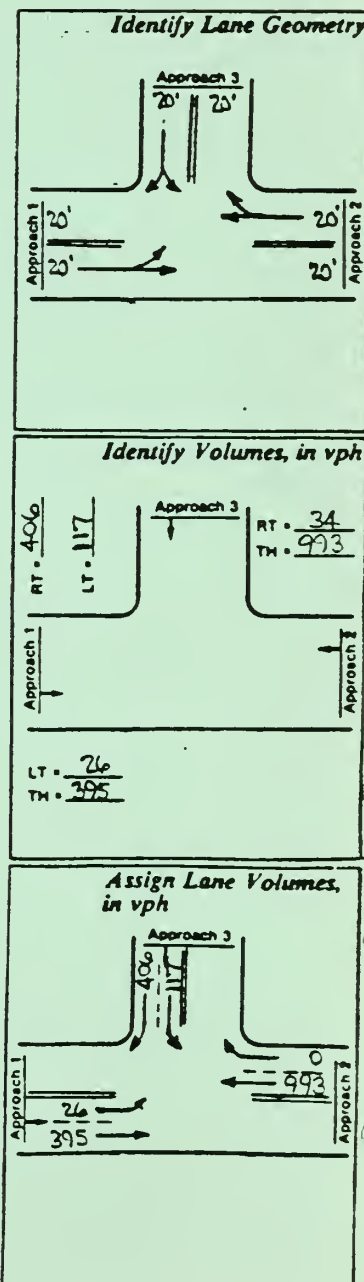
VOLUMES

APPROACH	A: Kendrick St			B: Kendrick st			C: Third Ave.		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	993	0	26	395	0	117	0	406
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00	
PASSENGER CARS		99.00			100.00			97.00	
PERCENT LT TRU		0.00			0.00			1.00	
PERCENT HV TRU		1.00			0.00			2.00	
PASS CAR/HR	0			26			120	0	416

STEP 1 RIGHT TURNS FROM	C:Third Ave.
CONFLICTING FLOWS	993
CRITICAL GAPS	5.0
CAPACITY	445
DEMAND	416
SHARED LANE	N
AVAILABLE RESERVE	28
DELAY	Very long delay
LOS	E

STEP 2 LEFT TURNS FROM	B:Kendrick st.
CONFLICTING FLOWS	993
CRITICAL GAPS	5.0
CAPACITY	445
DEMAND	26
CAPACITY USED	6
IMPEDANCE FACTOR	0.97
AVAILABLE RESERVE	419
DELAY	Little or no delay
LOS	A

STEP 3 LEFT TURNS FROM	C:Third Ave.
CONFLICTING FLOWS	1414
CRITICAL GAPS	6.5
CAPACITY	147
ADJUST FOR IMP	142
SHARED LANE THRU	N
SHARED LANE RIGHT	N
DEMAND	120
AVAILABLE RESERVE	22
DELAY	Very long delay
LOS	E



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

AM INSTALL SIGNAL AT THIRD AVE AND PERMIT OUTBOUND MOVEMENT ONLY FOURTH AVE ON E-WAY INBOUND

STEP ONE OUTPUT

	1	2	3
NAME	KENDRICK ST.	KENDRICK ST.	THIRD AVE.
#THRU LANES	2	2	0
AVG WIDTH	10	10	0
#LT LANES	0	0	1
AVG WIDTH	0	0	15
#RT LANES	0	0	1
AVG WIDTH	0	0	15

STEP TWO OUTPUT

	1	2	3
LT VOL	0	0	169
THRU VOL	1701	301	0
RT VOL	0	0	37
PED VOL	0	0	0
TRUCK %	0.8	1.0	0.9
BUS STOP	0	0	0

STEP FOUR OUTPUT

	1	2	3
CYCLE(secs)	60	60	60
CHANGE INT	60	60	60
LT CAP ON C1	120	120	120
G/C	.83	.83	.16
OP VOL	301	1701	0
LT CAP ON GR	695	0	192
LT TOT CAP	815	120	312
LT VOL	0	0	169
PASS CHK	t	t	t

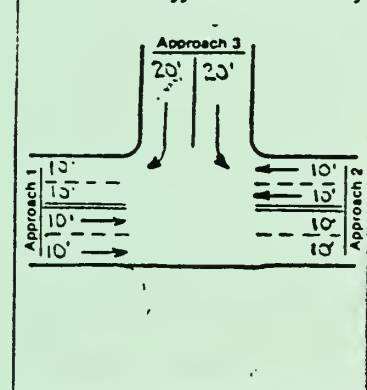
STEP SIX OUTPUT

	1	2	3
PHF	0.89	0.85	0.52
LT VOL	0	0	328
THRU VOL	1927	358	0
RT VOL	0	0	72

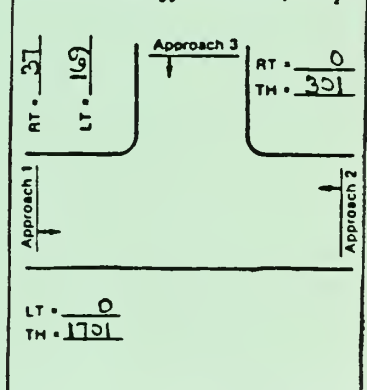
STEP SEVEN OUTPUT

	1	2	3
OP VOL	301	1701	0
PCE LTU	2.00	6.00	1.00
PCE LTP	1.20	1.20	1.05
PCE RT	1.00	1.00	1.00
UNPROTECT LT	328	344	
PROTECT LT	1927	1927	
A2B1	358	358	

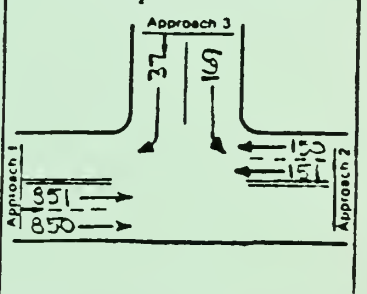
Identify Lane Geometry



Identify Volumes, in vph



Assign Lane Volumes, in vph



STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B4	295	310
A3**	65	65
A1B2	1011	1011
A2B1	188	188

** The critical lane volume occurs in the exclusive right turn lane(s)

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

1011	1-one phase only
1199	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

295	1-one phase only
375	2-two phase,one left protected,no overlap
310	3-two phases,one left protected,overlap
310	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LDS
1	1	0.73	1307	1800	C
1	3	0.77	1321	1720	C
1	8	0.77	1321	1720	C
1	2	0.81	1386	1720	D
8	1	0.87	1494	1720	D
8	3	0.91	1509	1650	E
8	8	0.91	1509	1650	E
8	2	0.95	1574	1650	E

CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

MID INSTALL SIGNAL AT THIRD AVE AND PERMIT OUTBOUND MOVEMENT ONLY FOURTH AVE O
E-WAY INBOUND

STEP ONE OUTPUT

NAME	1	2	3
KENDRICK ST.	KENDRICK ST.	THIRD AVE.	
#THRU LANES	2	2	0
AVG WIDTH	10	10	0
#LT LANES	0	0	1
AVG WIDTH	0	0	15
#RT LANES	0	0	1
AVG WIDTH	0	0	15

STEP TWO OUTPUT

	1	2	3
LT VOL	0	0	212
THRU VOL	439	311	0
RT VOL	0	0	137
PED VOL	0	0	0
TRUCK %	5.1	0.8	0.4
BUS STOP	0	0	0

STEP FOUR OUTPUT

	1	2	3
CYCLE (secs)	60	60	60
CHANGE INT	60	60	60
LT CAP ON CI	120	120	120
G/C	.50	.50	.49
OP VOL	311	439	0
LT CAP ON GR	289	161	588
LT TOT CAP	409	281	708
LT VOL	0	0	212
PASS CHK	t	t	t

STEP SIX OUTPUT

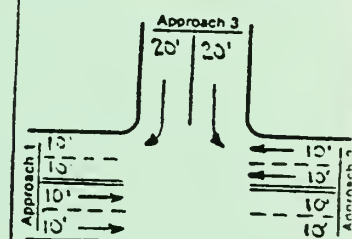
	1	2	3
PHF	0.88	0.89	0.73
LT VOL	0	0	292
THRU VOL	524	352	0
RT VOL	0	0	188

STEP SEVEN OUTPUT

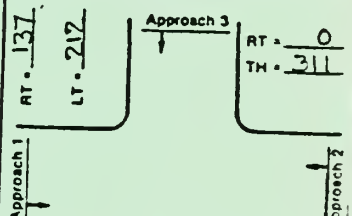
	1	2	3
OP VOL	311	439	0
PCE LTU	2.00	2.00	1.00
PCE LTP	1.20	1.20	1.05
PCE RT	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B4	292	306
A1B2	524	524
A2B1	352	352

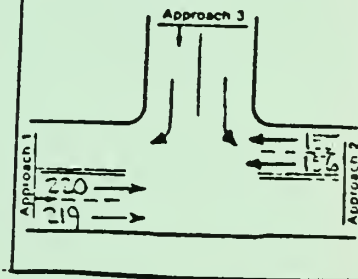
Identify Lane Geomet



Identify Volumes, in vph



Assign Lane Volumes, in vph



STEP EIGHT AND NINE A OUTPUT

UNPROTECT LT PROTECT LT

B4	262	276
A3**	170	170
A1B2	275	275
A2B1	185	185

** The critical lane volume occurs in the exclusive right turn lane(s)

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

275	1-one phase only
460	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

262	1-one phase only
445	2-two phase,one left protected,no overlap
276	3-two phases,one left protected,overlap
276	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1	1	0.30	538	1800	A
1	3	0.32	551	1720	A
1	8	0.32	551	1720	A
1	2	0.42	720	1720	A
8	1	0.42	723	1720	A
8	3	0.45	736	1650	A
8	8	0.45	736	1650	A
8	2	0.55	905	1650	A

DATE: 10-18-1985

TIME: 11:32:25

PM INSTALL SIGNAL AT THIRD AVE AND PERMIT OUTBOUND MOVEMENTS ONLY FOURTH AVE ONE-WAY INBOUND

STEP ONE OUTPUT

	1	2	3
NAME	KENDRICK	KENDRICK	THIRD
#THRU LANES	2	2	0
AVG WIDTH	10	10	10
#LT LANES	0	0	1
AVG WIDTH	0	0	15
#RT LANES	0	0	1
AVG WIDTH	0	0	15

STEP TWO OUTPUT

LT VOL	0	0	317
THRU VOL	421	795	0
RT VOL	0	0	604
RED VOL	0	0	0
TRUCK %	0.0	0.9	3.3
BUS STOP	0	0	0

STEP FOUR OUTPUT

CYCLE (secs)	60	60	60
CHANGE INT	60	60	60
LT CAP ON CI	120	120	120
G/C	.35	.35	.40
OP VOL	795	421	0
LT CAP ON GR	0	47	720
LT TOT CAP	120	167	840
LT VOL	0	0	317
PASS CHK	Yes	Yes	Yes

STEP SIX OUTPUT

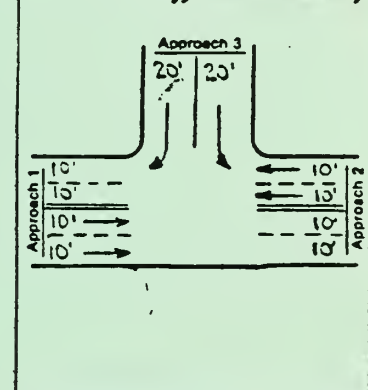
PDE	0.87	0.80	0.64
LT VOL	0	0	512
THRU VOL	484	1003	0
RT VOL	0	0	975

STEP SEVEN OUTPUT

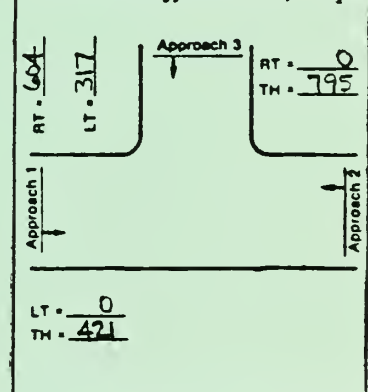
OP VOL	795	421	0
PDE LTU	4.00	2.00	1.00
PDE LTP	1.20	1.20	1.05
PDE RT	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B4 1-2	512	537
A1B2 --> -->	484	484
A2B1 <--< <--<	1003	1003

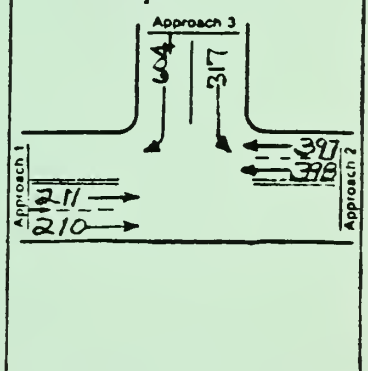
Identify Lane Geometry



Identify Volumes, in vph



Assign Lane Volumes, in vph



DATE: 10-18-1985

TIME: 11:32:42

PM INSTALL SIGNAL AT THIRD AVE AND PERMIT OUTBOUND MOVEMENTS ONLY FOURTH AVE ON E-WAY INBOUND

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B4 -->	460	484
A3 v **	877	877
A1B2 ---> ---^	254	254
A2B1 <-- v--	526	526

** The critical lane volume occurs in the exclusive right turn lane(s)

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

526	1-one phase only
780	8-two phases, directional split

POSSIBLE PHASES APPROACHES 3 & 4

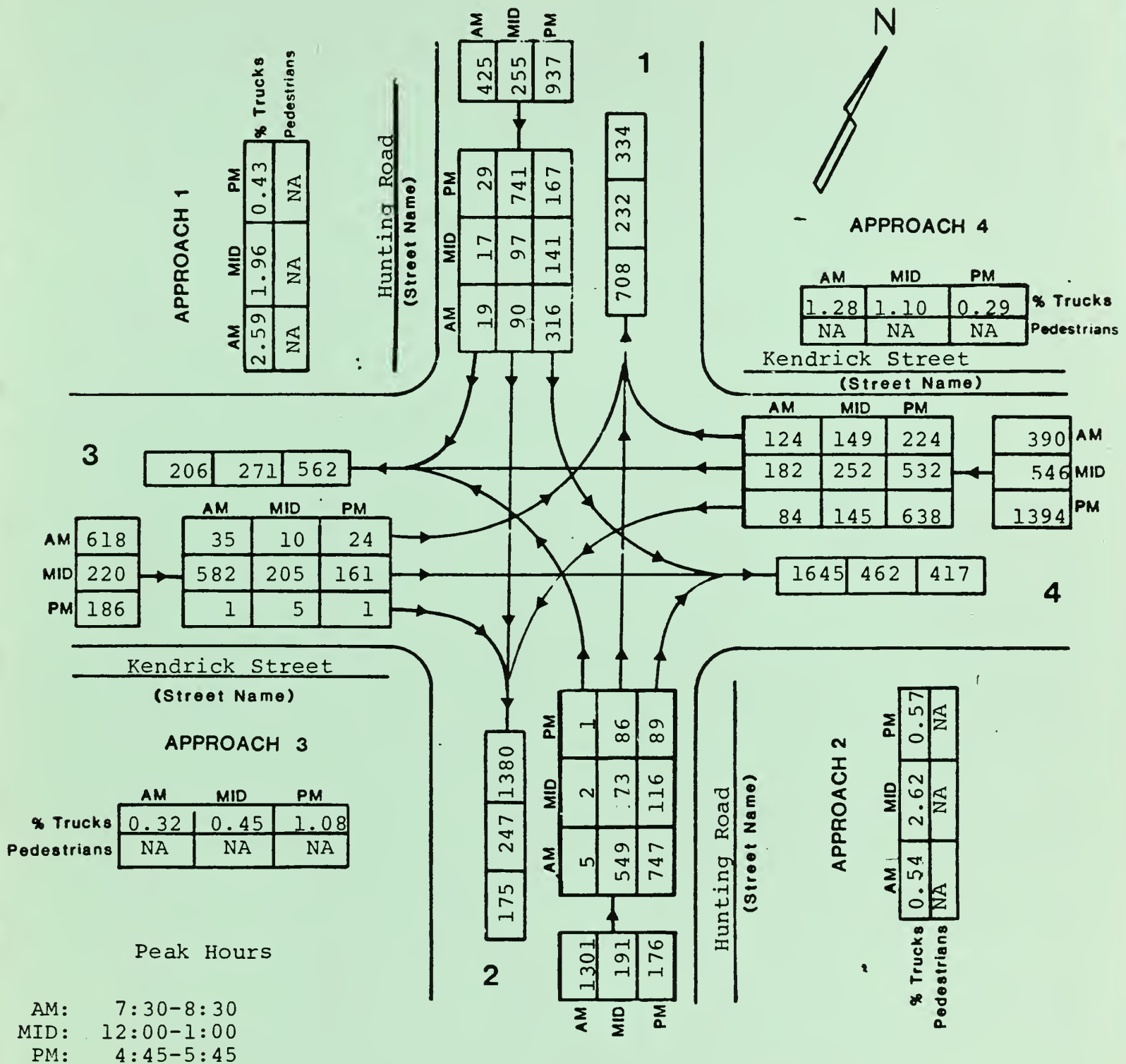
877	1-one phase only
1361	2-two phase, one left protected, no overlap
877	3-two phases, one left protected, overlap
877	8-two phases, directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1	1	0.78	1404	1800	C
1	7	0.82	1404	1720	D
1	8	0.82	1404	1720	D
8	1	0.96	1658	1720	E
8	8	1.00	1658	1650	F
8	7	1.00	1658	1650	F
1	2	1.10	1887	1720	F
8	2	1.30	2141	1650	F

SUMMARY OF VEHICLE MOVEMENTS

Intersection Hunting Road @ Kendrick Street

Date 9/19/84 Day of Week Wednesday Weather Fair 65°F Community Needham



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

A.M. Sept. '84

STEP ONE OUTPUT

	1	2	3	4
NAME	Kendrick St.	Kendrick St.	Hunting Rd.	Hunting Rd.
#THRU LANES	2	2	2	2
AVG WIDTH	9	13	13	10
#LT LANES	0	0	0	0
AVG WIDTH	0	0	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	35	84	316	5
THRU VOL	582	182	90	549
RT VOL	1	124	19	747
PED VOL	1	1	1	1
TRUCK %	0.3	1.3	2.6	0.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	72	72	72	72
CHANGE INT	50	50	50	50
LT CAP ON CI	100	100	100	100
G/C	.32	.32	.67	.67
OP VOL	306	583	1296	109
LT CAP ON GR	78	0	0	695
LT TOT CAP	178	100	100	795
LT VOL	35	84	316	5
PASS CHK	t	t	f	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.79	0.78	0.81	0.89
LT VOL	44	109	400	6
THRU VOL	739	236	114	620
RT VOL	1	161	24	844

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	306	583	1296	109
PCE LTU	2.00	2.00	6.00	1.00
PCE LTP	1.20	1.20	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
A1B2	829	794
A2B1	616	528
A3B4	2540	618
A4B3	1469	1470

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
A1B2	479	458
A2B1	291	250
A3B4	1200	292
A4B3	771	772

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

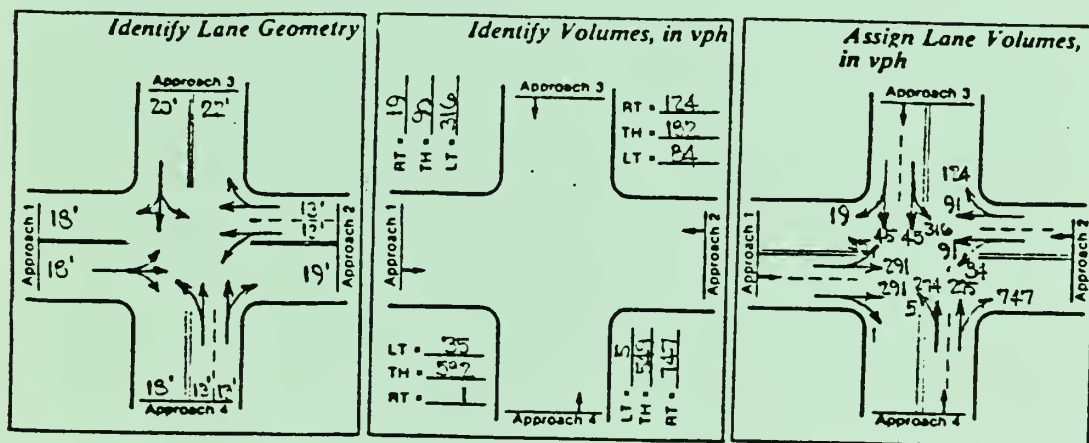
479	1-one phase only
708	8-two phases, directional split

POSSIBLE PHASES APPROACHES 3 & 4

1200	1-one phase only
1064	8-two phases, directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1	8	0.90	1543	1720	E
1	1*	0.93	1679	1800	E
8	8	1.07	1772	1650	F
8	1*	1.11	1908	1720	F

* This phasing may be inappropriate due to left turn restrictions see STEP FOUR OUTPUT above



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

MID Sept. '84

STEP ONE OUTPUT

	1	2	3	4
NAME	Kendrick St.	Kendrick St.	Hunting Rd.	Hunting Rd.
#THRU LANES	2	2	2	2
AVG WIDTH	9	13	13	10
#LT LANES	0	0	0	0
AVG WIDTH	0	0	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	10	149	141	2
THRU VOL	205	252	97	73
RT VOL	5	145	17	116
PED VOL	1	1	1	1
TRUCK %	0.5	1.1	2.0	2.6
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE (secs)	72	72	72	72
CHANGE INT	50	50	50	50
LT CAP ON CI	100	100	100	100
G/C	.68	.68	.31	.31
OP VOL	397	210	189	114
LT CAP ON GR	419	606	183	258
LT TOT CAP	519	706	283	358
LT VOL	10	149	141	2
PASS CHK	t	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.71	0.70	0.84	0.81
LT VOL	14	215	171	3
THRU VOL	290	364	118	92
RT VOL	7	209	21	147

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	397	210	189	114
PCE LTU	2.00	1.00	1.00	1.00
PCE LTP	1.20	1.20	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
A1B2	326	314
A2B1	789	832
A3B4	310	344
A4B3	242	242

STEP EIGHT AND NINE A OUTPUT

UNPROTECT LT PROTECT LT

A1B2	188	181
A2B1	373	393
A3B4	146	162
A4B3	127	127

STEP TEN OUTPUT

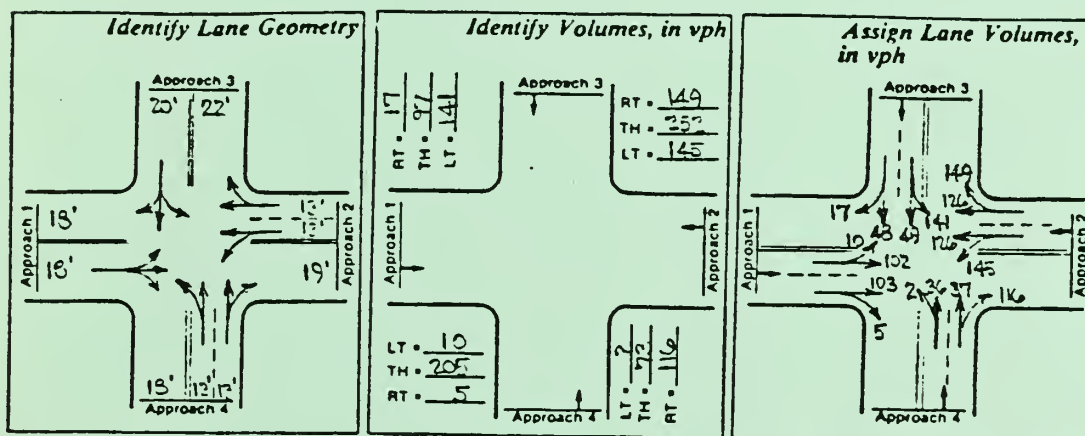
POSSIBLE PHASES APPROACHES 1 & 2

373	1-one phase only
574	8-two phases, directional split

POSSIBLE PHASES APPROACHES 3 & 4

146	1-one phase only
290	8-two phases, directional split

Existing Condition	Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
→ 1	1	1	0.29	519	1800	A
1	1	8	0.39	662	1720	A
8	8	1	0.42	721	1720	A
8	8	8	0.52	864	1650	A



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

P.M. Sept. '84

STEP ONE OUTPUT

	1	2	3	4
NAME	Kendrick St.	Kendrick St.	Hunting Rd.	Hunting Rd.
#THRU LANES	2	2	2	2
AVG WIDTH	9	13	13	10
#LT LANES	0	0	0	0
AVG WIDTH	0	0	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	24	638	167	1
THRU VOL	161	532	741	86
RT VOL	1	224	29	89
PED VOL	1	1	1	1
TRUCK %	1.1	0.3	0.4	1.1
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE (secs)	72	72	72	72
CHANGE INT	50	50	50	50
LT CAP ON CI	100	100	100	100
G/C	.59	.59	.40	.40
OP VOL	756	162	175	770
LT CAP ON GR	0	546	305	0
LT TOT CAP	100	646	405	100
LT VOL	24	638	167	1
PASS CHK	t	t	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.78	0.93	0.93	0.96
LT VOL	31	688	180	1
THRU VOL	209	574	800	91
RT VOL	1	242	31	94

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	756	162	175	770
PCE LTU	4.00	1.00	1.00	4.00
PCE LTP	1.20	1.20	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
A1B2	334	247
A2B1	1503	1641
A3B4	1012	1048
A4B3	189	186

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
A1B2	193	143
A2B1	710	775
A3B4	478	495
A4B3	99	97

STEP TEN OUTPUT

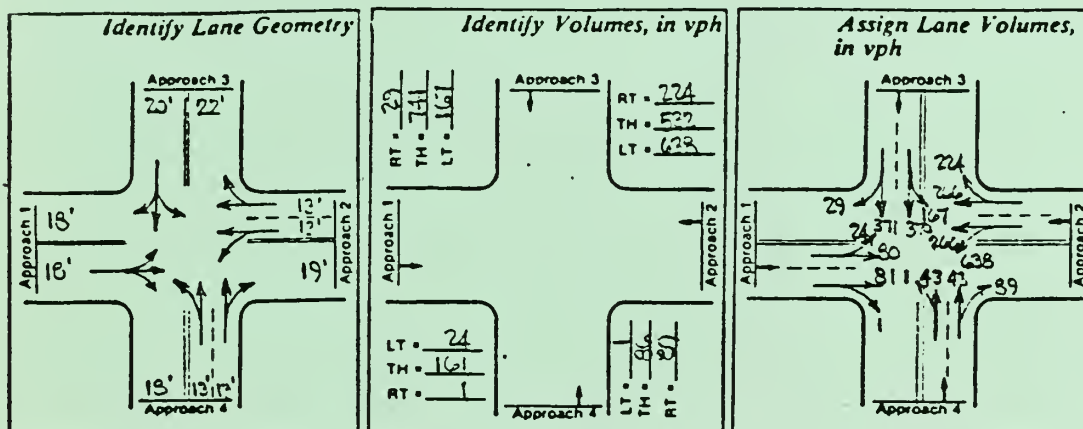
POSSIBLE PHASES APPROACHES 1 & 2

710	1-one phase only
918	8-two phases, directional split

POSSIBLE PHASES APPROACHES 3 & 4

478	1-one phase only
592	8-two phases, directional split

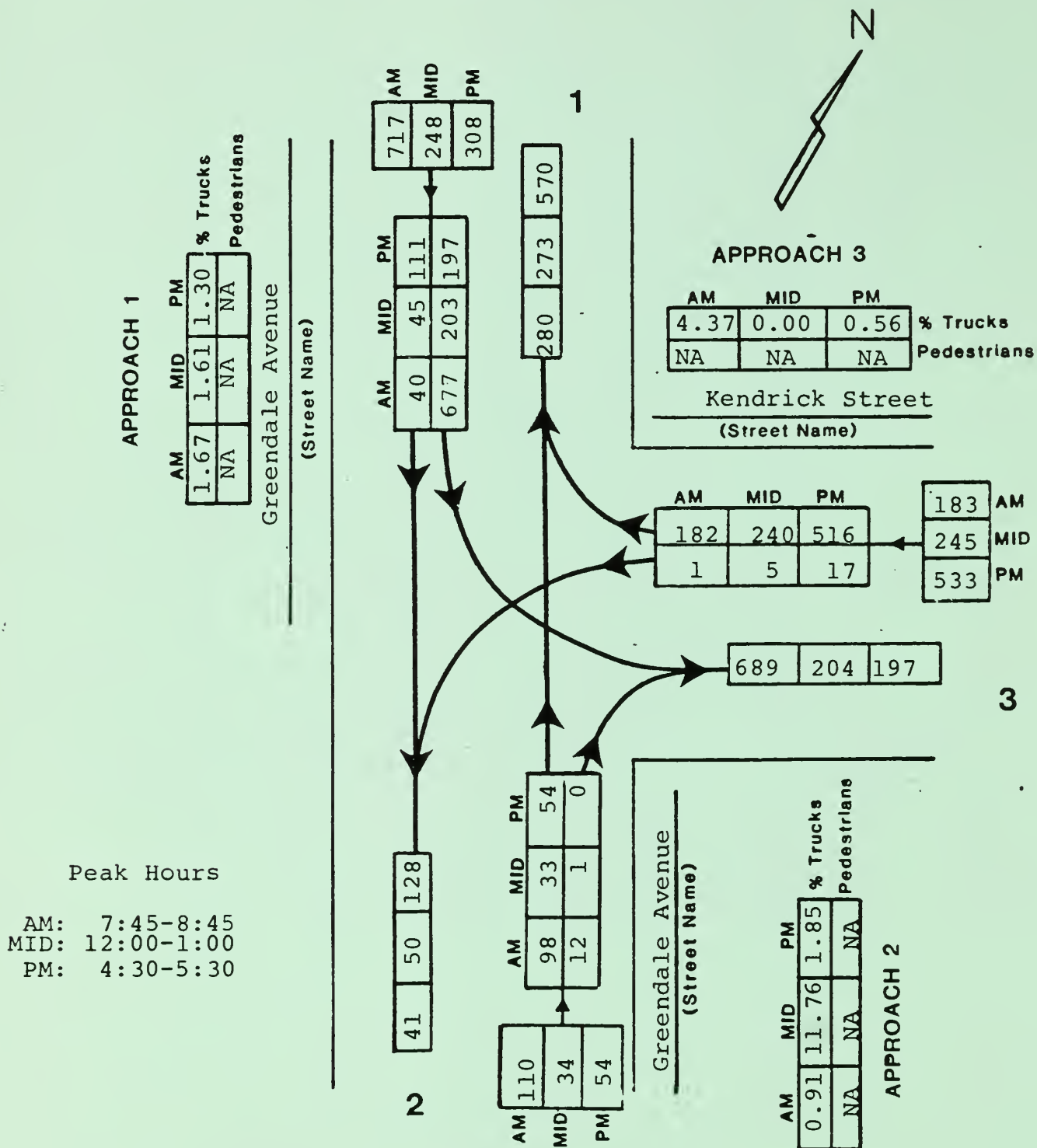
Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
Existing Condition → 1	1	0.66	1188	1800	B
1	8	0.76	1303	1720	C
8	1	0.81	1396	1720	D
8	8	0.92	1511	1650	E



SUMMARY OF VEHICLE MOVEMENTS

Intersection Greendale Avenue @ Kendrick Street

Date 9/20/84 Day of Week Thursday Weather Fair 65°F Community Needham



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

A.M. Sept. '84

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Kendrick St.

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

VOLUMES

APPROACH	A: Greendale			B: Greendale			C: Kendrick St		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	98	12	677	40	0	1	0	182
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00	
PASSENGER CARS		99.00			98.00			96.00	
PERCENT LT TRU		0.00			1.00			2.00	
PERCENT HV TRU		1.00			1.00			2.00	
PASS CAR/HR	0			687			1	0	187

STEP 1 RIGHT TURNS FROM
CONFLICTING FLOWS

C: Kendrick St.

104

CRITICAL GAPS

5.0

CAPACITY

1081

SHARED LANE

Y

STEP 2 LEFT TURNS FROM

B: Greendale Ave.

CONFLICTING FLOWS

110

CRITICAL GAPS

5.0

CAPACITY

1075

DEMAND

687

CAPACITY USED

64

IMPEDANCE FACTOR

0.43

AVAILABLE RESERVE

388

DELAY

Short traffic delay

LOS

B

STEP 3 LEFT TURNS FROM

C: Kendrick St.

CONFLICTING FLOWS

821

CRITICAL GAPS

6.5

CAPACITY

317

ADJUST FOR IMP

136

SHARED LANE THRU

Y

SHARED LANE RIGHT

Y

SHARED LN DEMAND

188

CAPACITY OF SHARED LN

1042

AVAILABLE RESERVE

854

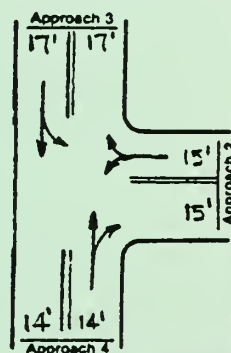
DELAY

Little or no delay

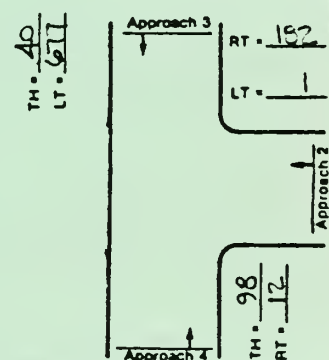
LOS

A

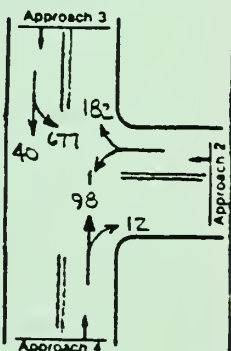
Identify Lane Geometry



Identify Volumes, in vph



Assign Lane Volumes, in vph



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

MID Sept. '84

GENERAL CHARACTERISTICS

CONTROLS: YIELD
PREVAILING SPEED: 30 MPH
MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Kendrick St.
EXCLUSIVE LEFT TURN LANES: N
EXCLUSIVE RIGHT TURN LANES: N

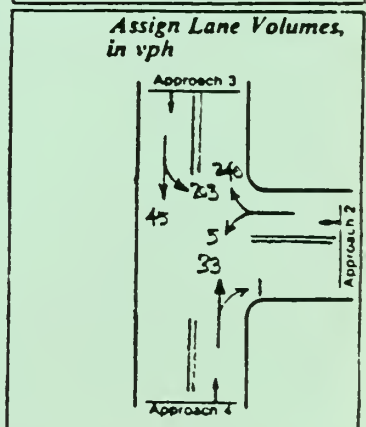
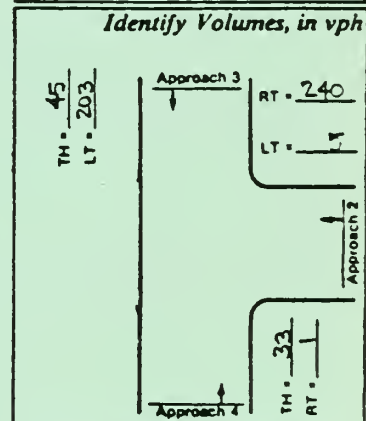
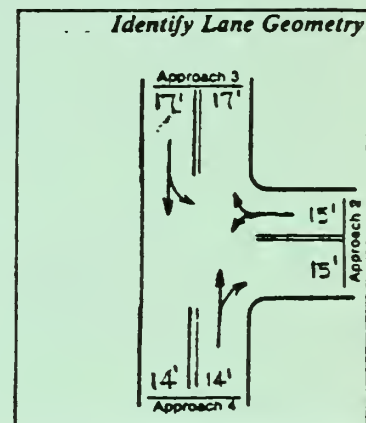
VOLUMES

APPROACH	A: Greendale			A B: Greendale			A C: Kendrick St		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	33	1	203	45	0	5	0	240
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00	
PASSENGER CARS		88.00			98.00			100.00	
PERCENT LT TRU		6.00			1.00			0.00	
PERCENT HV TRU		6.00			1.00			0.00	
PASS CAR/HR	0			206			5	0	240

STEP 1 RIGHT TURNS FROM	C:Kendrick St.
CONFLICTING FLOWS	34
CRITICAL GAPS	5.0
CAPACITY	1160
SHARED LANE	Y

STEP 2 LEFT TURNS FROM	B:Greendale Ave.
CONFLICTING FLOWS	34
CRITICAL GAPS	5.0
CAPACITY	1160
DEMAND	206
CAPACITY USED	18
IMPEDANCE FACTOR	0.88
AVAILABLE RESERVE	954
DELAY	Little or no delay
LOS	A

STEP 3 LEFT TURNS FROM	C:Kendrick St.
CONFLICTING FLOWS	282
CRITICAL GAPS	6.5
CAPACITY	640
ADJUST FOR IMP	562
SHARED LANE THRU	Y
SHARED LANE RIGHT	Y
SHARED LN DEMAND	245
CAPACITY OF SHARED LN	1136
AVAILABLE RESERVE	891
DELAY	Little or no delay
LOS	A



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

P.M. Sept. '84

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Kendrick St.

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

VOLUMES

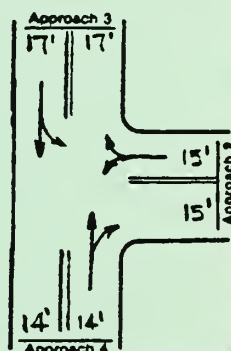
APPROACH	A: Greendale			B: Greendale			C: Kendrick St		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	54	0	197	111	0	17	0	516
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES	0.00			0.00			0.00		
PASSENGER CARS	98.00			99.00			99.00		
PERCENT LT TRU	1.00			0.00			0.00		
PERCENT HV TRU	1.00			1.00			1.00		
PASS CAR/HR	0			199			17	0	521

STEP 1 RIGHT TURNS FROM	C: Kendrick St.
CONFLICTING FLOWS	54
CRITICAL GAPS	5.0
CAPACITY	1137
SHARED LANE	Y

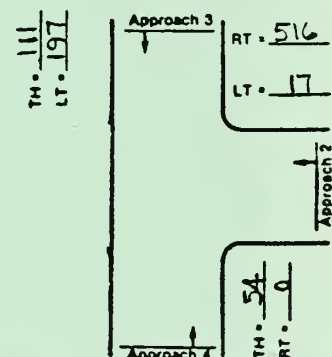
STEP 2 LEFT TURNS FROM	B: Greendale Ave.
CONFLICTING FLOWS	54
CRITICAL GAPS	5.0
CAPACITY	1137
DEMAND	199
CAPACITY USED	18
IMPEDANCE FACTOR	0.88
AVAILABLE RESERVE	938
DELAY	Little or no delay
LOS	A

STEP 3 LEFT TURNS FROM	C: Kendrick St.
CONFLICTING FLOWS	362
CRITICAL GAPS	6.5
CAPACITY	577
ADJUST FOR IMP	508
SHARED LANE THRU	Y
SHARED LANE RIGHT	Y
SHARED LN DEMAND	538
CAPACITY OF SHARED LN	1094
AVAILABLE RESERVE	555
DELAY	Little or no delay
LOS	A

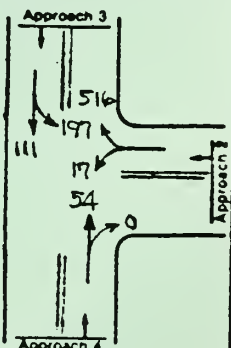
Identify Lane Geometry



Identify Volumes, in vph



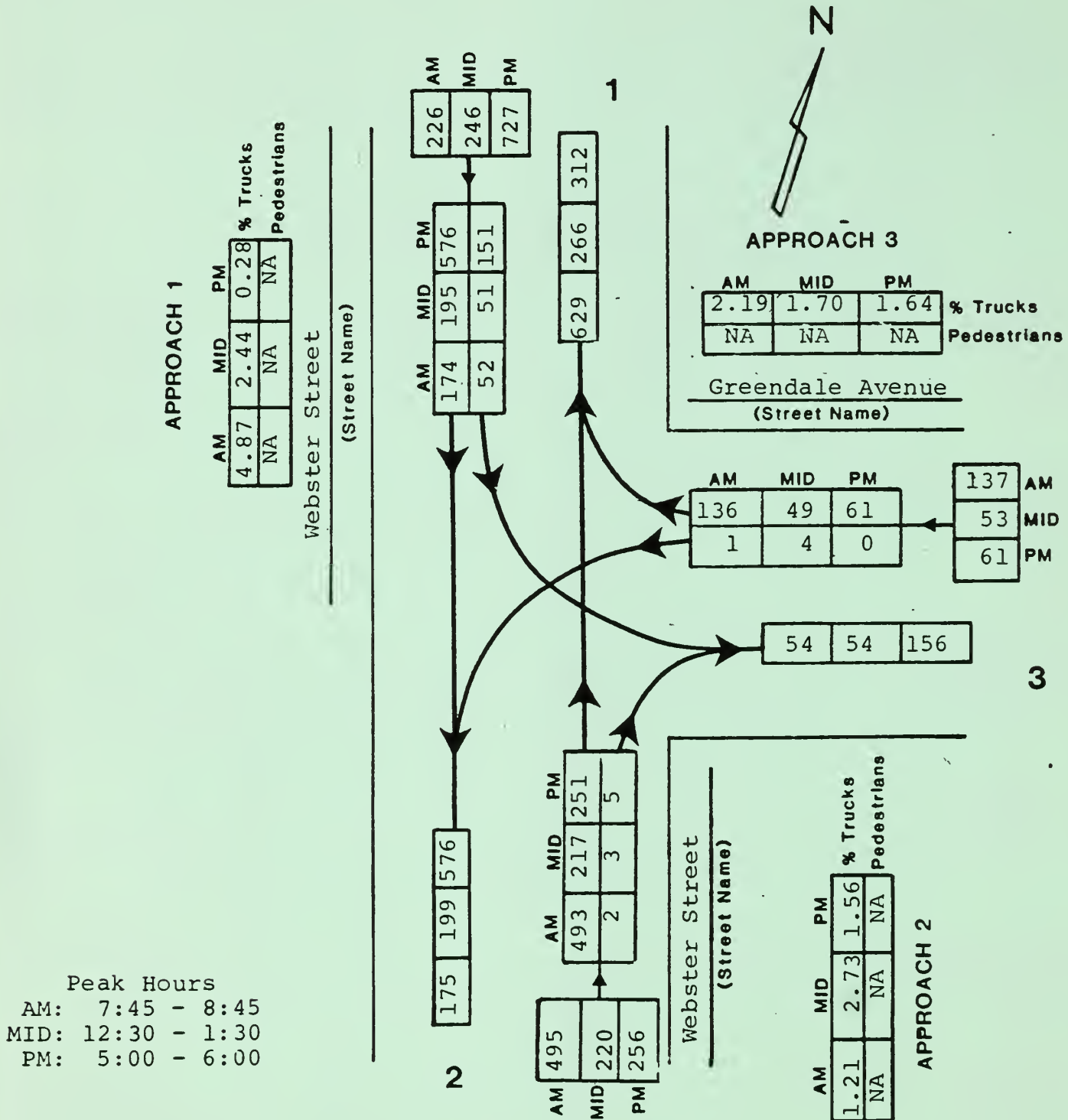
Assign Lane Volumes, in vph



SUMMARY OF VEHICLE MOVEMENTS

Intersection Webster Street @ Greendale Avenue

Date 9-19-84 Day of Week Wednesday Weather Fair 65°F Community Needham



1 ● CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

A.M. Sept. '84

GENERAL CHARACTERISTICS

CONTROLS: YIELD

1 ● PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Greendale Ave.

EXCLUSIVE LEFT TURN LANES: N

1 ● EXCLUSIVE RIGHT TURN LANES: N

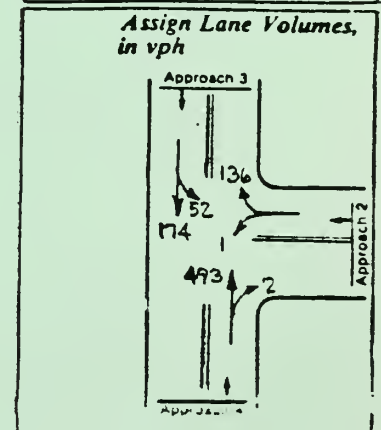
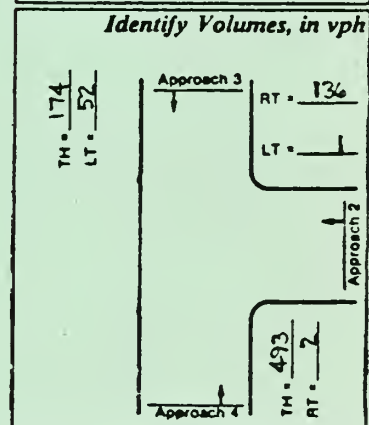
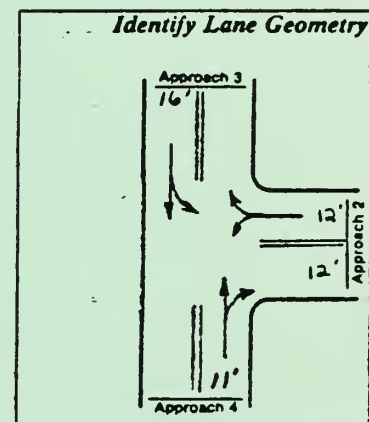
VOLUMES

APPROACH	A: Webster St.			B: Webster St.			C: Greendale A		
	LT	TH	RT	LT	TH	RT	LT	TH	RT
VOLUME	0	493	2	52	174	0	1	0	136
PERCENT GRADE	0.00			0.00			0.00		
PERCENT CYCLES		0.00			0.00			0.00	
PASSENGER CARS		99.00			95.00			98.00	
PERCENT LT TRU		0.00			2.00			1.00	
1 ● PERCENT HV TRU		1.00			3.00			1.00	
PASS CAR/HR	0			54			1	0	138

STEP 1 RIGHT TURNS FROM	C: Greendale Ave.
CONFLICTING FLOWS	494
1 ● CRITICAL GAPS	5.0
CAPACITY	732
SHARED LANE	Y

STEP 2 LEFT TURNS FROM	B: Webster St.
1 ● CONFLICTING FLOWS	495
CRITICAL GAPS	5.0
CAPACITY	731
DEMAND	54
CAPACITY USED	7
IMPEDANCE FACTOR	0.96
1 ● AVAILABLE RESERVE	677
DELAY	Little or no delay
LOS	A

STEP 3 LEFT TURNS FROM	C: Greendale Ave.
1 ● CONFLICTING FLOWS	720
CRITICAL GAPS	6.5
CAPACITY	362
ADJUST FOR IMP	347
SHARED LANE THRU	Y
SHARED LANE RIGHT	Y
1 ● SHARED LN DEMAND	139
CAPACITY OF SHARED LN	726
AVAILABLE RESERVE	587
DELAY	Little or no delay
LOS	A



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

MID Sept. '84

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Greendale Ave.

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

VOLUMES

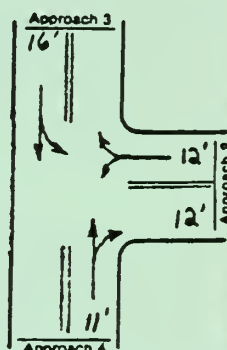
APPROACH	A: Webster St.			B: Webster St.			C: Greendale Ave.			A
	LT	TH	RT	LT	TH	RT	LT	TH	RT	
VOLUME	0	217	3	51	195	0	4	0	49	
PERCENT GRADE	0.00			0.00			0.00			
PERCENT CYCLES		0.00			0.00			0.00		
PASSENGER CARS		97.00			98.00			98.00		
PERCENT LT TRU		1.00			1.00			1.00		
PERCENT HV TRU		2.00			1.00			1.00		
PASS CAR/HR	0			52			4	0	50	

STEP 1 RIGHT TURNS FROM	C: Greendale Ave.
CONFLICTING FLOWS	219
CRITICAL GAPS	5.0
CAPACITY	964
SHARED LANE	Y

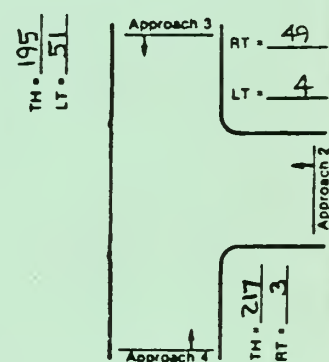
STEP 2 LEFT TURNS FROM	B: Webster St.
CONFLICTING FLOWS	220
CRITICAL GAPS	5.0
CAPACITY	963
DEMAND	52
CAPACITY USED	5
IMPEDANCE FACTOR	0.97
AVAILABLE RESERVE	911
DELAY	Little or no delay
LOS	A

STEP 3 LEFT TURNS FROM	C: Greendale Ave.
CONFLICTING FLOWS	465
CRITICAL GAPS	6.5
CAPACITY	505
ADJUST FOR IMP	490
SHARED LANE THRU	Y
SHARED LANE RIGHT	Y
SHARED LN DEMAND	54
CAPACITY OF SHARED LN	899
AVAILABLE RESERVE	845
DELAY	Little or no delay
LOS	A

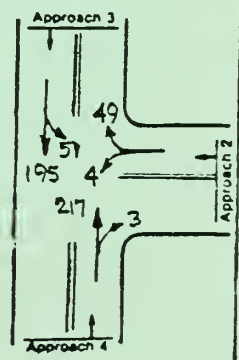
Identify Lane Geometry



Identify Volumes, in vph



Assign Lane Volumes, in vph



CIRCULAR 212 WORKSHEET: UNSIGNALIZED - 3 APPROACHES

P.M. Sept. '84

GENERAL CHARACTERISTICS

CONTROLS: YIELD

PREVAILING SPEED: 30 MPH

MAIN STREET # OF LANES: 2 LANES

MINOR STREET LANES

APPROACH: C: Greendale Ave.

EXCLUSIVE LEFT TURN LANES: N

EXCLUSIVE RIGHT TURN LANES: N

VOLUMES

APPROACH	A: Webster St.			B: Webster St.			C: Greendale Ave.			A
	LT	TH	RT	LT	TH	RT	LT	TH	RT	
VOLUME	0	251	5	151	576	0	0	0	61	
PERCENT GRADE	0.00			0.00			0.00			
PERCENT CYCLES		0.00			0.00			0.00		
PASSENGER CARS		98.00			100.00			98.00		
PERCENT LT TRU		1.00			0.00			1.00		
PERCENT HV TRU		1.00			0.00			1.00		
PASS CAR/HR	0			151			0	0	62	

STEP 1 RIGHT TURNS FROM C:Greendale Ave.

CONFLICTING FLOWS	254
CRITICAL GAPS	5.0
CAPACITY	931
SHARED LANE	Y

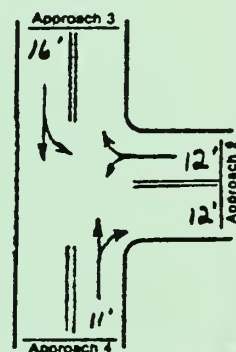
STEP 2 LEFT TURNS FROM B:Webster St.

CONFLICTING FLOWS	256
CRITICAL GAPS	5.0
CAPACITY	929
DEMAND	151
CAPACITY USED	16
IMPEDANCE FACTOR	0.89
AVAILABLE RESERVE	778
DELAY	Little or no delay
LOS	A

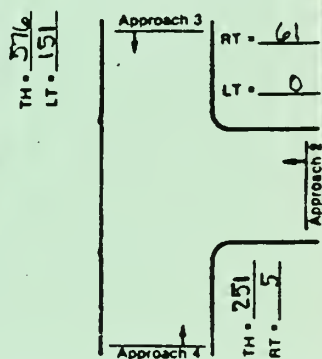
STEP 3 LEFT TURNS FROM C:Greendale Ave.

CONFLICTING FLOWS	981
CRITICAL GAPS	6.5
CAPACITY	258
ADJUST FOR IMP	230
SHARED LANE THRU	Y
SHARED LANE RIGHT	Y
SHARED LN DEMAND	62
CAPACITY OF SHARED LN	931
AVAILABLE RESERVE	869
DELAY	Little or no delay
LOS	A

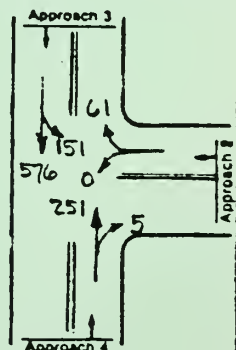
Identify Lane Geometry



Identify Volumes, in vph



Assign Lane Volumes, in vph



Appendix E

CTWLTML REVIEW MEMORANDUM

Appendix E

Description of Content

The Highland Avenue/Needham Street Corridor Consensus Committee proposed the construction of a five-lane section on segments of Highland Avenue and Needham Street to improve traffic flow and land use access within the study area. The proposed fifth lane would be a "Continuous Two-Way Left-Turn Median Lane" (CTWLTML).

As part of the effort to examine the feasibility of this kind of configuration current literature on the subject was researched and reviewed by CTPS. The findings of the research effort were documented in an internal CTPS memorandum that is printed in this appendix. The memorandum contains a brief summary of each of the issues concerning this kind of lane configuration from the perspective of the Highland Avenue/Needham Street study area.

MEMORANDUM

TO: Lawrence Tittlemore
FROM: William T. Steffens
RE: CTWLTML Review

August 10, 1984

Definitions

CTWLTML - Continuous Two-Way Left-Turn Median Lane

COWLTML - Channelized One-Way Left-Turn Median Lane

There are two types of COWLTML: raised and flush. When raised the median serves as a non-traversable barrier separating opposing and conflicting traffic movements. Flush channelization generally refers to the use of paint, buttons, tile or some other easily transversible delineator.

The CTWLTML is a center left-turn lane that provides a common space for vehicles traveling in either direction to change speeds and to queue for left-turn movements at any location along a two-way roadway. The COWLTML is a central left-turn lane that provides space for vehicles traveling in one direction to turn at designated locations along a two-way roadway.

Access Conditions¹

The concentration of left turns resulting from restrictive or nontraversable median controls is often undesirable. Such controls often result in an increase in U-Turns or in "around the block" traffic movements to reach destinations on the arterial non-accessible by direct left turns, and sometimes leads to considerable pressure from local businesses for additional more favorable median openings.

Traffic Volume

CTWLTML's have been constructed on two known seven lane facilities with 25,000-27,000 ADT. Literature research indicates reductions in accidents have occurred at CTWLTML's under varying volumes within the full 8,000-31,000 ADT. They are most commonly used on five lane facilities moving from 10,000 to 25,000 ADT.

Problem: As traffic volumes approach capacity, the gaps in opposing traffic become more limited - so the value of the CTWLTML for reducing congestion becomes questionable. That is,

traffic volumes as such may not always be a warrant for CTWLTML. On the contrary, volumes approaching roadway capacity in either direction may be a reason for not installing the two-way left turn lane. A more important consideration is the observation of time gaps of sufficient length for the left turn movement to be accomplished.

Speed Limit

Speed is not a governing factor. Speed higher than 25MPH seems appropriate to discourage the use of the center lane for passing.

Signing and Pavement Markings

In October, 1964 Peter Kaltnow in Traffic Engineering indicated, "CTWLTML's were being developed without fanfare or standards, without driver education without legal standards or names but those using them (practically) without exceptions reported that they work". The lack of signing and marking uniformity was described as so complete as to even defy the laws of chance - the success regardless of markings underscores their effectiveness. Guidelines for signing and pavement marking procedures to be used with CTWLTML have since been developed and are contained in the Manual on Uniform Traffic Control Devices, sections 3B-12 and 2B-17.

Proper Use

Use of the CTWLTML is reserved for vehicles in the main stream of traffic to enter for the purpose of deceleration and storage in preparation for making a left turn into properties abutting the arterial. It is not intended to be used for passing and overtaking or travel. However, use of the lane for acceleration by left turning vehicles entering the main flow from a driveway or intersection is yet a point of contention, but is considered by most traffic engineers to be a proper use.

Since the CTWLTML is available for simultaneous use by vehicles traveling in opposite directions it presents drivers with an unusual situation foreign to the normal driving experience. It is therefore, particularly important to educate the public in how to use the lane properly.

In an evaluation of driver use of CTWLTML's the Georgia Division of the ITE concluded that "a significant percentage of left-turning drivers use the lane improperly." The primary faults included:

- o use of an excessive length;
- o stopping in or turning left from through lanes;
- o driving accross pointed channelization at terminal ends.

The findings further point up the need for reliable education of the public in proper use.

Documented Experience

Cincinnati CTWLTML: Four-lanes restriped to five lanes. Department store and many other traffic generators do not attract traffic until after the morning peak hour traffic has subsided; during the day through traffic becomes relatively less important. Consequently, the conflict between the access function and the movement function becomes most critical during the evening peak hour.

The case concluded, CTWLTML benefits were most pronounced as volumes increased. The effect of volume on speed was more significant on the four-lane roadway.

In Mansfield North evaluation: Two lanes restriped to three lanes. Introduction of a lane even at the expense of narrowing each of the original two lanes by 4 feet considerably improved the safety of the roadway and resulted in considerably increased running speeds.

Alternatives to Control Conflicts at Access Points²

Conflicts arise from the need for provision of access to abutting properties and the efficient movement of traffic.

Tactics to minimize the severity of conflicts:

- Reduce speed limit.
- Increase turning and merging speeds by high standard driveway design - provide acceleration and deceleration lanes.
- Channelize driveway vehicles to enter and leave at small angles.
- Eliminate sight restrictions.

Density of conflicts can be reduced by:

- Elimination of redundant driveways.
- Consolidation of driveways.
- Provision of one-way operation on nearby driveways where inner circulation is available.

To reduce the frequency of conflicts:

- Control spacing between driveways to minimize conflicts between vehicles from adjacent driveways, (hard to do after the fact).

- Control clearance between driveways and intersections to minimize conflicts between driveway vehicles and intersection vehicles.
- Provide channelization to physically separate driveway vehicles from the arterial and prevent their encroachment or re-entry into the through lanes (eg. separation of driveway ingress vehicles onto a deceleration lane or left turn slot).
- Install channelized left-turn bays on the arterial roadway to shadow left-turning vehicles from rear-end conflicts.

More drastic alternatives:

- Eliminate driveways and provide access to nearby collectors.
- Change driveway operation to one-way enterings and provide exits on nearby collectors to meet the arterial at controlled intersections.
- Construct a frontage road.
- Construct a median divider and prevent left turns.
- Install one-way operation on the arterial.

Access to Property

In general, operational problems at mid-block locations relate to a lack of or improper control of access. Too many driveways, poor driveway design and the lack of acceleration - deceleration lanes reduce the quality of traffic flow and safety on the facility. On such streets, these conditions exist in the vicinity of the intersections and result in reduced capacity.

The most critical problem with mid-block access is the left-turn maneuver into a driveway. One obvious correction is the introduction of a barrier type median that prohibits the mid-block left-turn. However, this generally is not a practical solution where access has already been granted.

When barrier medians are used, and direct access to land is not permitted, circuitous problems in gaining access to the land can develop. U-turns at the intersection are impractical and unsafe. Access by "circling the block" can be provided by the proper street layout. The most desirable means, however, is to encourage access from a side street after turning left at an intersection.

Some observers have advanced the idea that the CTWLTML increases the capacity of intersections by reducing the number of left-turns to be accommodated. The rationale is that turns permitted at mid-block would have otherwise been routed through the intersection to gain access.

Among the possible alternatives for increasing capacity two-way left turn lanes are considered among small capacity increase alternatives. Large capacity increase (50%) system management alternatives include: one-way operation; reversible flow; and left-turn prohibition. Small capacity increases of less than 25% include: unbalanced flow; two-way left-turn lane, and provision for protected left turns.

The design of the two-way left turn lane is to remove vehicles waiting to turn left from through travel lanes. Since left-turns into roadside commercial areas declines during peak periods the reduction in trip time is probably rather small. (Nevertheless, in areas where through traffic is approaching saturation, even a low number of lefts being made consistently during the peak period can lead to significant performance reductions. This situation occurs during the PM peak period on Needham Street and Highland Avenue.)

On Needham Street and Highland Avenue the PM peak direction is westbound. Two conditions seem to cause extensive queueing sometimes for the entire length of the corridor. First, conflicts are created by left-turns from Highland Ave. onto Wexford Street either for U-turns or legitimate access to Wexford Street. Left-turning traffic from the Second Avenue intersection becomes blocked and backs up through the signal.

As the signal changes phase neither direction of Highland Avenue can move until the Second Avenue traffic clears the intersection. The cycle failure effects of this situation disrupts northside (westbound) Highland Avenue traffic most.

The second problem location is the Oak Street/Christina Street intersection in Newton. In the absence of police details this intersection can become the control point for all Needham Street traffic. The severity of congestion being left-turn volume dependent.

Operational Performance

Before-and-after studies of CTWLTML by Nemeth et.al., (1976) included the review of two different treatments. The first involved the conversion of a four lane arterial into three-lanes the third lane being a CTWLTML. The conclusion of the analysis was that conversion resulted in increased travel time, increased weaving and some reduction in total conflicts.

In the second case a four-lane roadway was converted into a five-lane section. The analysis showed an increase in volumes with an insignificant change in travel speeds. Conflicts as measured by braking to avoid contact declined by 19 percent.

This treatment was also found to create additional capacity within the existing right-of-way enabling greater volumes of traffic to use the facility without reducing travel times. In effect, traffic using alternate routes prior to implementation will return to the improved facility. The resultant effect should be a reduction in total VMT and of traffic intrusion on residential streets.

Accident Experience³

Walton et.al., (TRR, 737) used a multiple regression technique to predict accident rates on CTWLTML. The equation predicts number of accidents per mile on the basis of ADT, city population, number of driveways per mile and number of signals per mile. The r^2 is approximately .75 with a standard error of estimate of 33.

Under present conditions Highland Avenue annually averages approximately 124 accidents per mile for the three years ending 1983. Over the same time period Needham Street averaged approximately 183 accidents per mile. Application of Walton's equation to the Highland Avenue/Needham Street corridor assuming implementation of a CTWLTML and installation of traffic signals at Oak Street and Christina Street and at Marshall's Plaza, indicates the potential for a substantial reduction in total accidents. The expected number of accidents per mile under the assumed scenario would total approximately 86 per year. Applying the standard error of estimate from the original analysis a realistic range of 53 to 119 accidents per mile per year can be expected. (Derivation of these results is contained in Appendix A.)

There were too few examples of COWLTML to develop a similar equation, however, the authors did compare the actual accident experience of the COWLTML with an equation estimated CTWLTML. The calculated accidents per mile were consistently higher than the actual experience, however, the estimates were within an average error of -33.4.

The analysis suggests the possibility of an additional margin of safety of COWLTML over the CTWLTML. This may stem from a reduction in the number of potential conflicts of the COWLTML as compared to the CTWLTML.

Operational Conflicts

Theoretically, five types of operational conflicts have been identified on a CTWLTML:

1. Head-on conflict.
2. Conflict between a vehicle in the CTWLTML and a left-turning vehicle from a inner street.
3. Conflict between a vehicle in the CTWLTML and a vehicle beginning to enter the CTWLTML.
4. Conflict between a left-turning vehicle not in the CTWLTML and a through moving vehicle.
5. Conflict between a vehicle in the CTWLTML and a through moving vehicle.

With a flush COWLTML only three potential conflicts have been identified:

1. Conflict between a left-turning vehicle and a straight through vehicle from the through lane.
2. Conflict between a left-turning vehicle in the left-turn lane and a left turning vehicle from the opposite direction.
3. Conflict between a left-turning vehicle and a straight through vehicle in the opposite direction.

With a raised COWLTML only one type of conflict is likely, that between a left-turning vehicle and a through vehicle in the through lane.

Summary:

1. General accident statistics for raised COWLTML sites and CTWLTML sites indicate similar patterns by hour of day, number of vehicles involved and severity.
2. Raised COWLTML sites have a greater proportion of intersection and intersection related accidents than do CTWLTML.
3. The most frequently noted factor contributing to accidents on CTWLTML and raised COWLTML are unsafe speed and failing to yield right of way.
4. CTWLTML related accidents are of lower severity than non-CTWLTML sections.

5. CTWLTML lane widths of 11 feet and 12 feet have no significant adverse effect on traffic operations, but 15 foot or greater lane widths create some confusion among drivers.
6. In reference to flush COWLTML's lane widths of 10.5 to 12.5 feet showed no significant operational variation.
7. Lane widths of 8 ft. 6 in. to 10. ft 6. in for COWLTMLs produced significant variations.
8. There is a wide range of entrance distances on CTWLTMLs. The majority of drivers observed entered the CTWLTML 150-250ft from the intersection, while very few drivers entered the lane less than 30m (100ft) from the intersection.
9. Although there is a range of maneuvering distances, a large number of observed drivers completed the left-turn entry in 50ft.
10. Maneuvering distances are shorter at midblock than at intersection approaches.

In conclusion, observers have found the fear of conflicts and resultant increase in accidents after implementation of CTWLTML's to be unfounded. In fact, most "anticipated" conflicts rarely occur; if they occur they are handled with typical driver judgement.

It was also observed that the signing and pavement-marking procedures in the Manual on Uniform Traffic Control Devices, (sections 3B-12 and 2B-17) are effective in informing drivers of CTWLTML operations. Also, speed limits imposed on many CTWLTML serve little purpose.

In regard to raised or flush COWLTML, no significant driver-conflict problems were observed.

OBSERVED CONDITIONS IN USE

	CTWLTML	COWLTML
ADT	10,000-20,000 (4-Lane) 5,000-12,000 (2-Lane)	14,400-31,000 (4-Lane) >10,000 (in general)
Speed	30 - 50 MPH	≥ 30 MPH
Widths	10 - 15 ft.	12 ft.

	CTWLTML	COWLTML
Land use	Commercial or industrial w/commercial	Not as important
Change in Accidents	-6 to 38% in before/after -35% in regression model	-28% in regression model

OPERATIONS AND CAPACITY EFFECTS

1. Conversion of four-lane arterial into a three-lane section
result: increased travel times
increased weaving
reduction in total conflicts
2. Conversion of four-lane section into a five-lane section
result: increased volumes
insignificant change in speed
decline in braking related conflicts

Survey of Texas SDHPT & City Engineers⁴

CTWLTML preferred in areas of demand for:

- midblock left turns
- peak through traffic volume
- strip commercial land use
- through traffic speed of more than 30 MPH
- long block spacing
- abutting retailers preference

COWLTMLS preferred where:

- sight distance is restricted
- pedestrian movements

Bibliography

1. Nemeth, Zoltan A., "Development of Guidelines for the Application of Continuous Two-Way Left-Turn Median Lanes. (Ohio State University, Report No. Ohio-DOT-09-76 July 1976).
2. National Highway Institute, "Alternatives for Improving Urban Transportation," 1977, (Federal Highway Administration, Pawtucket, Rhode Island).
3. Walton, C. Michael et.al., "Accident and Operational Guidelines for Continuous Two-Way Left-Turn Median Lanes", (Transportation Research Board, Transportation Research Record 737).
4. Walton, C. Michael et.al., "Design Criteria for Median Turn Lanes", Research Report 212-1F (Center for Highway Research University of Texas at Austin, 1978)

Appendix F

MEETING NOTES AND RELATED MEMORANDUM

Appendix F

Description of Content

Included in this appendix are several documents that were generated previous to and as part of the study of existing conditions.

In the order of appearance are:

- December 17, 1982 letter from community leaders and Newton-Needham Chamber of Commerce to the Massachusetts Department of Public Works (MDPW) outlining the plan proposed by the Highland Avenue/Needham Street Corridor Consensus Committee
- April 26, 1983 letter from the Metropolitan Area Planning Council (MAPC) to the MDPW suggesting a feasibility study of the plan submitted by the two communities
- May 10, 1983 letter from the City of Newton to MAPC endorsing the suggestion of a feasibility study
- May 18, 1983 letter from the Town of Needham to MAPC endorsing the suggestion of a feasibility study
- July 1, 1983 internal memorandum of the Town of Needham announcing the scheduled time of a meeting with MDPW officials
- August 5, 1983 letter with meeting notes attached from the City of Newton to the MDPW which discuss an August 2nd interagency meeting
- July 18, 1984 letter from the communities and the Chamber of Commerce requesting a postponement of the CTPS turning movement count survey
- September 24, 1984 meeting notes from the consulting firm of Lozano, White and Associates to the Needham Street Corridor Task Force
- October 1, 1984 meeting notes from CTPS to meeting attendees discussing preliminary findings from the study of existing conditions
- January 23, 1985 memorandum from CTPS to the MDPW regarding the CTPS review of the Vanasse/Hangen Site Impact Analysis for 160 Gould Street in Needham

- February 1, 1985 internal memorandum of the Town of Needham pertaining to a CTPS briefing on existing conditions problems and solutions
- June 12, 1985 letter from the Newton-Needham Chamber of Commerce to the MDPW requesting an update on the status of the Highland Avenue-Needham Street project
- October 3, 1985 announcement of a special meeting of the Highland Avenue-Needham Street Task Force
- February 3, 1986 letter from the Highland Avenue-Needham Street Task Force responding to the draft "existing conditions" report
- April 7, 1986 letter with memorandum from CTPS to Highland Avenue-Needham Street Task Force responding to their comments on the "existing conditions" report
- April 24, 1986 letter from the Executive Office of Transportation and Construction (EOTC) to Representative Susan D. Schur apprising her of the progress made in addressing the issues of the Highland Avenue-Needham Street corridor
- June 2, 1986 letter from CTPS to MDPW discussing potential improvements to the Needham Street/Oak Street/Christina Street intersection in Newton
- July 10, 1986 memorandum from CTPS to the MDPW summarizing agreements reached for short-range improvement of Highland Avenue and Needham Street
- July 15, 1986 notes of a meeting held for CTPS to present the conclusions and recommendations of the "existing conditions" report to Representative Susan Schur and officials from the MDPW
- July 16, 1986 letter from CTPS to the MDPW discussing potential improvements to the Needham Street/Oak Street intersection



NEWTON-NEEDHAM

CHAMBER OF COMMERCE, INC.

437 CHERRY STREET • NEWTON, MASSACHUSETTS • 02165

AREA CODE 617 • 244-5300

December 17, 1982

Mr. Sandino J. Tersigni, Commissioner
Massachusetts Department of Public Works
100 Nashua Street
Boston, Massachusetts 02114

Dear Commissioner Tersigni:

At our meeting on September 22, 1982 among you and your staff, officials from the City of Newton and the Town of Needham, representatives of local business and concerned citizens you cited the lack of a consensus on how to improve the Highland Avenue/Needham Street Corridor as a major obstacle for State involvement in the project in the near future. In demonstrating the commitment and concern of the communities and area businesses, we pledged the efforts of our Engineering and Planning staffs and business representatives to develop a consensus, conceptual plan which would serve as the basis for future detailed design and engineering for corridor improvements.

The concept plan, which is attached for your consideration, represents the efforts of the communities and businesses over the past 12 weeks. Five meetings were convened in order to discuss the various components of the project and to achieve resolution.

We believe our efforts have produced a plan which will address the major traffic problems in the Highland Avenue/Needham Street Corridor in a manner which is not only technically feasible, but acceptable.

It is hoped that our efforts have eliminated the lack of consensus on corridor improvements and that we may see further actions taken on this project whose implementation has eluded us for over the past decade.

Very truly yours,

Theodore Mann
Mayor
City of Newton

H. Phillip Garrity
Chairman
Board of Selectmen
Town of Needham

Lewis B. Songer
Exec. Vice President
Newton-Needham
Chamber of Commerce



ACCREDITED

Page 2

3) Improvements to Highland Ave.-Needham Street

- a) Reconstruction of the existing roadway from Route 128 to Route 9 to include construction of a 72' roadway of four lanes (two in each direction) of 12' width with a lane for turning and including sidewalks. (See Illustration #2).
- b) Establishment of storage capacity at key points to allow for turning movement of commercial and passenger vehicles.
- c) Consolidation of curb cuts where feasible.
- d) Encourage the relocation of some loading docks.
- e) Encourage additional offstreet parking to permit traffic flow and remove parking on state-owned land.
- f) Installation of traffic signals at First Ave., Oak & Christina, Winchester St. and the Centre Street ramps at Route 9 to assure proper traffic flow and increase pedestrian safety.

Summary Focus:

In essence, it is agreed that these improvements meet the needs of business and private traffic, improved access to Route 128 and free flow of vehicles, as well as providing improved pedestrian safety. Most importantly, it will help preserve existing jobs and allow orderly development for future economic growth. It is to be emphasized that approximately 50% of the private sector jobs are within a two mile radius of this corridor in both communities. It is essential that we preserve what we have and enhance it.

Attachment #1

Technical Committee

Town of Needham- Russell Burke, Planning Director
John Marr, Town Engineer
Richard Robinson, Traffic Engineer

City of Newton- Lewis Branzburg, Economic Development Planner
Barry Canner, Planning Director
Paul Giunta, City Engineer
Donald Quinn, Construction Engineer
Donald Silverson, Director of Economic Development
David Tannozzini, Traffic Engineer

Newton-Needham Chamber of Commerce-

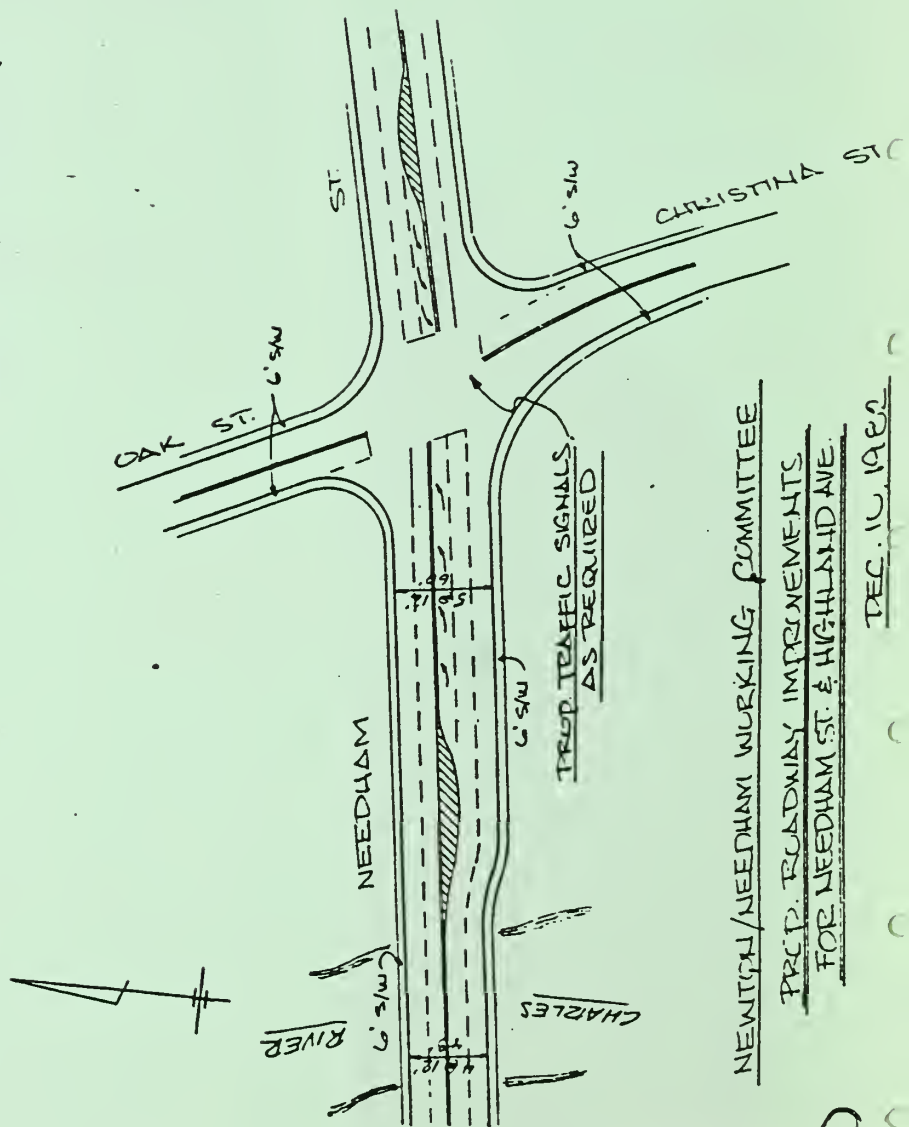
John Fox, GTE Sylvania: Chairman, Highland Ave.-Needham St.
Task Force
Stanley Colembe, Itek Corp., V.P. Economic Development
Lewis B. Songer, Executive Vice President

Attachment #2

Meeting Schedule (1:30 p.m. meetings)

October 14	Newton City Hall
October 28	Newton City Hall
November 10	Needham Public Works Dept.
November 29	Newton City Hall
December 9	Needham Public Works Dept.

NOTE: DETAIL TYPICAL FOR ENTIRE LENGTH OF ROADWAY.



NEWTON/NEEDHAM WORKING COMMITTEE

PRCP. ROADWAY IMPROVEMENTS
FOR NEEDHAM ST. & HIGHLAND AVE.

DEC. 10, 1962



Metropolitan Area Planning Council

110 Tremont Street Boston, Massachusetts 02108 (617)-451-2770

Serving 101 Cities & Towns in Metropolitan Boston

cc - Russ Baker
cc - Dave Tamm

April 26, 1983

Commissioner Robert T. Tierney
Mass. Department of Public Works
100 Nashua Street
Boston, MA 02114

Dear Commissioner Tierney:

On March 8, 1983, representatives of the Town of Needham, the City of Newton and the local Chamber of Commerce wrote to you expressing the need for highway improvements in the Needham Street - Highland Avenue corridor and Route 128. A copy of their letter is attached.

The proposed improvements described in that letter represent the latest efforts by Newton and Needham to address the traffic problems of the area. This agency believes that their concerns merit further examination.

As you may know, MAPC has had a continued interest in the problems of this area. In February, 1980, CTPS published the Highland Avenue/Needham Street Reconnaissance Report. Recently, MAPC and CTPS, in conjunction with the Newton-Needham Chamber of Commerce, conducted an employer-based ridesharing program for the area's employers.

We recommend that a feasibility study be conducted as a cooperative effort by the MDPW's Bureau of Transportation Planning and Development, MAPC and CTPS. It should include an analysis of land development, traffic generated by proposed improvements and traffic operations in the area. The study would ultimately determine whether the plan presented by the two communities would resolve the problems which have been of long standing concern in this area or whether some other action may be more appropriate.

MAPC would be happy to work with you and your staff by providing relevant data and any other assistance as may be needed. Please feel free to contact me or Ed Bates, MAPC's Transportation Coordinator, at 451-2770, if we can provide further information.

Sincerely,

Alexander V. Zaleski
Executive Director

AVZ:EB:jtg
Attachment

cc: Mayor Theodore D. Mann, Newton
Norman P. Jacques, Chairman, Board of Selectmen, Needham
Elizabeth A. Bransfield, MAPC President
David Jackson, MAPC Representative, Newton
Norman Homsy, Needham Representative
Lewis B. Songer, Exec. Vice President, Newton/Needham Chamber of Commerce



THEODORE D. MANN
MAYOR

City of Newton, Massachusetts

Incorporated 1873

CITY HALL

COMMONWEALTH AVENUE AND WALNUT STREET
NEWTON CENTRE 02159

TELEPHONE
552-7100

cc to Bob Pat ✓

May 10, 1983

Mr. Alexander Zaleski, Executive Director
Metropolitan Area Planning Council
110 Tremont Street
Boston, MA 02108

Dear Mr. Zaleski:

I am writing in reference to your letter of April 26, 1983 to Massachusetts DPW Commissioner Robert Tierney regarding the Needham Street-Highland Avenue Corridor. We appreciate your cooperation. In these times of dwindling public resources, cooperation between the state and local level is essential.

I am delighted that you shared with us the urgency of our problems on Needham Street. The Concept Plan which you reviewed reflects the consensus of engineers, planners, public officials, and the business community. The Plan is based on design concepts developed in conjunction with the Massachusetts Department of Public Works. I refer you to two sources: The Highland Avenue/Needham Street Reconnaissance Report, February 1980, prepared by the Central Transportation Planning Staff, and the preliminary design map, prepared by the Massachusetts DPW in February, 1982. The Concept Plan reflects these preliminary estimates of rights-of-way, road alignments, land damages, and other physical constraints in the corridor.

I believe it is now necessary to further the process with functional designs. I would welcome your assistance in the development of engineering plans, specifications and cost estimates for the project. My staff is available to meet with you at your earliest convenience to discuss the next phase of the design process. Please contact Donald Silverson, Economic Development Director, at 552-7135, to arrange such a meeting.

Again, thank you for your assistance. Clearly the traffic congestion which exists in the corridor is not only unsafe, but represents the primary obstacle to economic growth in the area. I look forward to working with you toward a satisfactory solution to the problem.

Sincerely,


Theodore D. Mann
Mayor

cc: Commissioner Robert Tierney, Mass. Dept. of Public Works
Rep. Susan Schur
Norman P. Jacques, Chairman, Board of Selectman, Needham
David Jackson, MAPC Representative, Newton
Lew Songer, Executive Vice-President, Newton-Needham Chamber of Commerce



TOWN OF NEEDHAM
MASSACHUSETTS

Office of
BOARD OF SELECTMEN

May 18, 1983

Mr. Alexander Zaleski, Executive Director
Metropolitan Area Planning Council
110 Tremont Street
Boston, MA 02108

Discuss with
Bob Pct.
MDPW station

Dear Alex:

On behalf of the Town of Needham I would like to express our appreciation for your support of the Highland Avenue/Needham Street corridor project as stated in your letter of April 26, 1983 to MDPW Commissioner Tierney.

The Town of Needham and the City of Newton have long sought relief to the growing traffic congestion in this area. Recognizing the importance this area represents in terms of jobs and tax base to the communities and region, the Town of Needham and City of Newton have coordinated their efforts with the input of the business community in preparing the Highland Avenue-Needham Street concept plan. This plan represents not only a solution to existing problems, but a framework to coordinate future development with circulation improvements.

The Town of Needham, along with the City of Newton is willing to meet with you and your staff to discuss joint efforts in forwarding this project. Such a meeting can be coordinated with our Planning Director, Russell Burke.

Please accept our thanks for your interest and involvement in seeking a solution to this local and regional problem.

Very truly yours,

Norman P. Jacques

Norman P. Jacques, Chairman
Needham Board of Selectmen

NPJ:kd

cc: Commissioner Robert Tierney, MDPW
Theodore D. Mann, Mayor of Newton
Norman A. Homsy, MAPC Representative, Needham
Lewis B. Songer, Newton-Needham Chamber of Commerce

Alec - FYI

- Russ has asked
me to attend.

Go → Ed

MEMO

TO: Harold W. Noble, Executive Secretary, Board of Selectment

FROM: Russell J. Burke, Needham Planning Director

DATE: July 1, 1983

SUBJECT: Highland Avenue-Needham Street Corridor

Please be advised that a meeting with DPW Commissioner Tierney and his Chief Engineer has been scheduled for July 12, 1983 at 2:00 p.m. in Room 410 of 100 Nashua Street. Representatives of Needham, Newton, and the Chamber of Commerce have been invited.

The purpose of the meeting is to hear the MDPW response to the Concept Plan submitted earlier in the year.

RJB:jh

✓ CC: Mr. Ed Bates

MAPC Transportation Planning Manager



CITY OF NEWTON, MASSACHUSETTS

CITY HALL
1000 COMMONWEALTH AVENUE
NEWTON CENTRE 02159
TELEPHONE (617) 552-7135

DEPARTMENT OF PLANNING AND DEVELOPMENT BARRY C. CANNER, DIRECTOR

August 5, 1983

Commissioner Robert Tierney
Massachusetts Department of Public Works
100 Nashua Street
Boston, MA 02114

Dear Commissioner Tierney:

Attached for your information are notes of an interagency meeting of engineers and planners held on August 2, 1983 regarding the upgrading of Needham Street/Highland Avenue. The meeting was fruitful, in part, thanks to the cooperative attitude displayed by your agency and all of the agencies represented.

Sincerely,

Donald Silverman
Economic Development Director

cc: Rep. Susan D. Schur
Rep. Connovan
Bob Kelley, MDPW
Selectman Hersey, Town of Needham
✓ Arnie Soolman, CTPS
Mayor Theodore D. Mann, Newton
Russ Burke, Needham Planning
Phil Lynch, Middlesex County
Ed. Bates, MAPC
Lew Songer, Newton-Needham Chamber of Commerce

DS/dd

Meeting Notes: Upgrading of Needham Street /Highland Avenue

8/2/83, 10:00 a.m. at Metropolitan Area Planning Council (MAPC)
110 Tremont Street, Boston

Attendance: See attached list.

Silverson: Short background presentation.

Kelley: Concept Plan is unique due to the configuration of five lanes without a median barrier. Especially since it is innovative design and due to the extent of land damages involved, land use and traffic studies are prerequisite. Studies should document existing conditions as well as projections under various alternatives.

Issues to be considered include local vs. through traffic volumes, interaction with Rt. 128, and left hand turning motions.

MDPW is in the process of selecting a consultant to study the alteration of access to Rt. 128(north and south bound) in the vicinity of Kendrick Street. That study will be completed more than a year from now.

Soolman: CTPS can perform traffic studies, including turning counts. However, staff will not be available at least until September, and scheduling thereafter depends on relative priority of this project. Assistance from Newton and Needham with data collection (traffic counters and existing archival data) would expedite the work.

Shouldn't studies of Needham Street/Highland Avenue be conducted simultaneously with studies of the Rt. 128 interchange so that data is complete and consistent?

Kelley: Yes, but local street data might justify the need for an expanded interchange, so the local study should be done as soon as possible.

Bates: Discontinuity of data would be a problem, but a phased approach might be more pragmatic than all or nothing.

Marr: Needham has no funds to commit, but will provide staff to assist CTPS.

Silverson: Newton will also provide staff.

Giunta: Newton has a lot of miscellaneous data, already collected for other projects, which could be used by CTPS.

Branzburg: Note also that the study area ought to include the Nahanton/Winchester Street area of Newton, which is prone to development.

Soolman: CTPS will initiate the appropriate studies as soon as possible, given other priorities. Within the next month, the agency will prepare a detailed work program to enable Newton and Needham to start gathering archival data and scheduling staff time for traffic counts.

Kelley: In the meantime, Newton and Needham should work on the historical assessment of the bridge. The environmental assessment should be done after the preliminary land use, traffic, and road design studies are completed.

The Middlesex County baseline study should be delayed until design options have been selected.

Soolman Further contacts with CTPS can be made with Dan Beagan, Supervisor of Traffic Engineering.

8/2/83

Attendance

Lewis Braseburg	Newton Planning	552-7135
Donald Silveison	Newton Planning	552-7135
Ed Bates	MHPC	451-2770
RUSSELL J. BURKE	NEEDHAM PLANNING	444-5100 x126
Larry Titterton	CTPS	451-5785
BOB PEYERS	CTPS	451-5785
Phil Lynch	Middlesex County	494-4141
PAUL W. GIUNTA	NEWTON CITY ENGINEER	552-7096
John D. MARR	NEEDHAM TOWN ENGINEER	444-5100 x-141
Bob Kelley	MASS D.P.W.	727-8274
Arnie Soolman	CTPS	451-5785

July 18, 1984

Mr. Alexander Zaleski, Executive Director
Metropolitan Area Planning Council
110 Tremont Street
Boston, Massachusetts 02108

Dear Mr. Zaleski:

We are writing on behalf of the Chamber of Commerce, the Town of Needham and the City of Newton regarding plans for monitoring and recording turning movements in conjunction with the concept plan for the Highland Avenue-Needham Street corridor during the next few weeks.

It is our opinion that local conditions are substantially different in the summer, not only because of employee vacations from the firms in the corridor, but also because daytime traffic for shoppers is substantially different. We therefore request a brief postponement until September.

Finally, it should be noted that two major business uses (Federal Express and Dimensions, Inc.) are beginning operations within the month. The traffic effects from their operations are important.

For these reasons, although we do not wish to unduly delay the project, it seems to make sense to request a short delay in recording turning movements to assure better, more accurate data.

Thank you for your consideration.

Sincerely,

Russell Burke
Planning Director
Town of Needham

Barry Canner
Planning Director
City of Newton

Lewis B. Songer, CCE
Executive Vice President
Newton-Needham Chamber
of Commerce

LBS/ho



9/24/84

Lozano, White and Associates
Architecture · Urban Design · City Planning

MEMO: To Needham Street Corridor Task Force

From: Eduardo Lozano and Roberta Leary

Re: Notes of September 20 Task Force Meeting,
Agenda for October 4 Task Force Meeting

1. Notes of Sept. 20 Meeting

Purpose of Meeting: Introduction of Lozano, White and Associates (LWA) to Task Force; outline purpose and scope of project; receive initial concerns and comments from committee.

E. Lozano - Outlined the purpose and scope of the project being conducted by LWA as follows. The purpose of the project is to develop a concept plan to guide development of properties along Needham Street. The major focus is upon uses of properties in the corridor, or land use -- such as retail, manufacturing, etc. -- because land use patterns are the major source of traffic congestion, safety and other problems.

The need for a concept plan is illustrated by the changes now taking place in the corridor. Maintaining the corridor as it is today is impossible, given current development pressures. For example, as much as 600,000 square feet of new development is planned or rumoured now. All this is occurring without a plan. Current zoning of the corridor allows intensive development of a wide variety of uses. More uncontrolled development will make existing problems worse.

A concept plan will help the city guide the corridor's development. It will take into account the interests of businesses, residents and the needs of the city, and will include zoning and other controls to carry out the plan.

In developing the plan, LWA will outline a series of alternatives, or "scenarios", and will evaluate the effects of each on the city's tax base, existing businesses, traffic and safety, employment and the neighborhood.

The project parallels another study of Needham Street being done by the Central Transportation Planning Staff (CTPS) for the Mass DPW. This latter study deals with reconstruction of Needham Street, and is a feasibility analysis of the "Concept Plan" developed by the City, the Chamber of Commerce and other groups. The two studies are

complementary: LWA's work will provide the CTPS with land use projections to evaluate the effects of the concept plan.

The role of the Task Force in the LWA project is to give direction to the consultants, to critique specific proposals, and to give guidance on community participation and reaction.

Public workshops to enable broad community input into the study will be held September 26 (7:30 pm, Emerson Gym) and October 10 (7:30 pm, Honeywell).

Comments

L. Songer: Emphasize study's focus on land use, not traffic. The "Concept Plan" (see above) has already been developed to deal with traffic. Suggests Needham planner be invited to Task Force.

L. Bransburg: Explained City does not yet have a plan for Corridor, and that such a plan is the purpose of the LWA study.

V. Niccollazzo: Maintenance of current uses in Corridor desirable. Consultants should bring specific plan to Task Force.

L. Richards: Traffic congestion hurts existing businesses.

T. Sullivan: The policy of city is forcing manufacturing tenants out. Only retailers can afford current levels of taxes.

T. Walsh: Traffic problems severe for residents.

R. Friend: Involvement of residents in plan is essential. Suggests written agenda for next meeting.

2. Agenda for Meeting of October 4 (8 am, City Hall, Rm. 222)

Purpose of meeting : Evaluation of development scenarios for Corridor; Update on CTPS Study

8:00 am - Presentation by LWA of development scenarios:
land uses, effects on traffic, taxes, existing
business, neighborhood quality

8:30 am - Discussion

9:00 am - Update of CTPS Traffic Study

9:30 am - Adjourn



ATTENDANCE

September 20, 1984

Mirick Friend	McDonald's	965-4240
Lew Songer	Chamber of Commerce	244-5300
Michael Malec	Alderman	969-5031
Cary Everett	Resident (south)	965-0654
Nan Laurence	NUFCDC	332-9075
James Miller	Planning/Development	244-3200
Thomas Sullivan	T&H Realty	244-1157
Steven Gainsboro	Ava Botelle	964-1913
Victor Nicollazzo	Bigelow Oil Co.	964-1600
Lincoln Richards	Arklay S. Richards Co.	527-1512
Lewis Bransburg	Newton Planning Dept.	552-7135
Terence Walsh	Residential Comm.	244-5149
Eduardo Lozano	Lozano, White and Assoc.	868-6344
Roberta Leary	Lozano, White and Assoc.	868-6344



central transportation planning staff

10 park plaza

room 2150

boston, ma.

02116-3968

(617) 973-7100

Notes on Meeting
Update of Needham Street/Highland Avenue Feasibility Study
October 1, 1984

B. Steffens opened the meeting with a short briefing on the CTPS field work that had been completed thus far. CTPS planners have been invited to attend a meeting sponsored by Lozano, White and Associates who were hired by the City of Newton to develop land use recommendations for the Needham Street Corridor.

L. Tittlemore described the preliminary findings based on the work completed to date:

1. Building Set-back Survey

In several cases buildings along Needham Street and Highland Avenue are built up to the MDPW 60-foot right-of-way. Therefore, significant land taking can be expected if a 72-foot cross section (five 12-foot lanes, and two 6-foot sidewalks) is constructed.

L. Brandzburg then mentioned a February 1982 proposal of the MDPW to widen Needham Street and Highland Avenue which included an alternative with a 72-foot cross-section which could be constructed without taking existing buildings. CTPS agreed to review the MDPW plan. Subsequent review of those plans indicate that it may be possible to provide a 72-foot cross-section without conflict with existing store fronts.

2. Accident Record Research

Review of local police (1981-1983) and MDPW (1976-1981) accident records indicates that several safety problems exist at the Wexford Street/Highland Avenue intersection in Needham. While more detailed analysis needs to be completed, it appears that the heavy demand for U-turns by traffic leaving the New England Industrial Park from First Avenue, that occurs at this point, has created an unsafe situation.

It was pointed out that the concept plan calls for opening the median barrier on Highland Avenue which presently blocks First Avenue. While it may be true that this action would solve the U-turn problem it would also require installation of a traffic signal which would be extremely hazardous to traffic on the adjacent Route 128 ramp system.

3. Turning Movement Count Survey

CTPS conducted a survey of turning movements at selected intersections in the study area between September 18th and 20th. The results of the survey will be used to assess the existing levels of congestion and to determine the potential for traffic diversion under various frontage road alternatives.

The attached map was then distributed and possible short-range improvements along the Needham Street/Highland Avenue corridor were discussed.

Preliminary examination of operating conditions along Needham Street and Highland Avenue suggest that major expansion of the roadway to five lanes as called for in the concept plan is not needed under existing conditions. Rather, existing problems with traffic congestion appear more closely related to operating conditions at a number of key locations.

In Newton, the Needham Street intersections with Oak Street and Christina Street and with Winchester Street and Dedham Street merit attention. To improve operations at each, CTPS will consider signalization and geometric upgrading.

In Needham, the Highland Avenue intersections with Second Avenue and with First Avenue also appear to be the cause of traffic problems which occur periodically. To alleviate these, CTPS will investigate the possibilities of upgraded channelization and signal retiming at Second Avenue, in conjunction with improvements at First Avenue.

It was further noted that the presence of peak period traffic queues which extend across either side of Cook's Bridge are due to the existence of capacity problems experienced at the intersections to either side. The improvements proposed for Oak Street and Christina Street at Needham Street and for Second Avenue at Highland Avenue should alleviate the queuing problem.

At this point, an extended discussion was launched as to how the frontage road and the Route 128 projects would best be pursued. B. Kelly pointed out that any frontage road construction must necessarily fall within the MDPW layout.

It was finally agreed that a frontage road alternative would be considered in both the CTPS study and the MDPW Route 128 project. It was also agreed that implementation of the two projects (frontage road, Route 128) should proceed independently.

Following this, the discussion focused on land use considerations. Both R. Burke and L. Branzburg clarified the posture of their communities toward greater selectivity in choosing the types of future land use which will be permitted in the area. B. Patneau pointed out the need for communities to

consider R-O-W acquisition in land use planning, and further stated that the MDPW cannot be expected to build highways which are intended to foster business development in a particular area. The community representatives noted that each is currently faced with proposals which could conceivably add 500,000+ square feet of development to the study area.

Both also confirmed that the land use planning presently taking place does not call for "upzoning" in anticipation of implementation of the concept plan.

L. Songer raised the issue that the Needham Street/Highland Avenue corridor was originally intended to extend to the west from the intersection of Winchester Street with Route 9. CTPS agreed to include that portion of Winchester Street between Needham Street and Route 9 in the study.

Finally, it was agreed that CTPS would release an Interim Report. The report will contain recommended solutions to existing problems which can be implemented quickly, and will identify possible permanent solutions to the problems which exist at First Avenue.

B. Kelly was asked to investigate the nature of funds which have been legislatively earmarked for use in conjunction with the Highland Avenue/Needham Street project.

As compiled from notes

Bill Luff

Highland Avenue - Needham Street
Update Meeting
10/1/84

Bill Steffens	CTPS
Dan Beagan	CTPS
Bob Kelley	MDPW, BPD
Lew Songer	Newton-Needham Chamber of Commerce
Ed Bates	MAPC
Carol Blair	MAPC
Larry Tittmore	CTPS
Robert Patneaude	MDPW
Russell J. Burke	Needham Planning Board
Lewis Branzburg	Newton Planning Dept.

MEMO

TO: PLANNING BOARD and BOARD OF SELECTMEN

FROM: Russell J. Burke, Planning Director

DATE: February 1, 1985

SUBJECT: Highland Avenue / Needham Street Corridor Project Status

On Wednesday, January 30, 1985 Jack Marr and I met with staff of the Central Transportation Planning Staff (CTPS) to discuss their progress to date in their feasibility study of the Highland Avenue/Needham Street Corridor.

The Massachusetts Department of Public Works (MDPW) has instructed CTPS to perform a feasibility analysis of the consensus Corridor Plan. That is, will the plan accomplish its stated objectives? Secondly, MDPW has instructed CTPS to identify short and long term components.

Having completed their analysis of existing conditions, CTPS presented some of their preliminary findings and short term strategies to Jack and me. Jack and I emphasized the fact that while we recognize that the 128 frontage road is by its nature a long term component, it is nonetheless an integral component of the concept plan. The frontage road has been included into the scope of the Route 128 widening project which is presently being undertaken by MDPW.

Among some of the findings and suggested short term solutions of CTPS are:

1. Based upon the analysis of existing conditions it appears as though the frontage road concept is feasible and will accomplish a reduction of surface traffic on Highland Avenue;
2. It does not appear feasible that a cut in the median with or without signalization is feasible to permit traffic exiting First Avenue to turn left onto west bound Highland Avenue;
3. The intersection of Highland Avenue and Wexford Street is the most dangerous in the corridor due to the left and illegal U turns which are made by vehicles;
4. Contrary to previous belief, the bridge at the Charles River is not a bottleneck for traffic nor does it require widening. Traffic moves without delay over the bridge even with the merging necessitated by its narrowing. The bottleneck occurs at the intersections on either side of the bridge (Oak and Christina in Newton and Highland and Second in Needham). CTPS feels that the existing bridge has sufficient capacity to handle the traffic which passes through the intersections;
5. In order to eliminate the left turn and U turn motions of eastbound traffic on Highland Avenue, a jug handle or loop road is being explored.

Such a road would travel between First and Second Avenues behind the buildings along the foot of the ledge (Jack Marr, Dick Robinson, and I were surprised to find upon field investigation that it could be physically constructed). Another variation of this concept could be a road which runs from First Avenue and comes out onto Highland Avenue lining up with Wexford Street. In any event such configurations could solve the left turn difficulties presently being experienced;

6. An exclusive left turn lane is being considered for west bound Highland Avenue at its intersection with Second Avenue. Such a lane would increase capacity of through traffic through the intersection and reduce backups into Newton;

7. The realignment of Second Avenue and Charles Street to create a four way intersection has been examined. However, building demolition and land taking issues could be prohibitive;

8. Cutting under the rail embankment to connect the Wexford/Charles Street area with Reservoir Street and Central Avenue is being examined as a means to provide alternative access to reduce demand from Highland Avenue;

9. The desirability/possibility of a connecting road between Third and Fourth Avenues at the present termination of B Street is being examined. Such a connecting road could assist in improving the function of the intersections with Kendrick Street. While these intersections function well at present, CTPS comments that this is one of the few areas in Needham where traffic measures can be implemented before, rather than after, traffic problems arise.

CC: David Owen, Executive Secretary
Robert A. MacEwen, Director, Public Works Department
Jack Marr, Town Engineer
Dick Robinson, Traffic Engineer
Bill Steffen, CTPS
Larry Tittlemore, CTPS
Lew Songer, Newton-Needham Chamber of Commerce



MEMORANDUM

TO: Michael Meyer, Director
MDPW/BTP&D

January 23, 1985

FROM: Lawrence Tittlemore, CTPS

RE: Review of Vanasse/Hangen Site Impact Analysis for 160
Gould Street in Needham, Mass.

ATTN: Robert Kelley, MDPW/BTP&D
Robert Patneaude MDPW/BTP&D

At the request of the Town of Needham Planning Department (Russell Burke, Planning Director), a request officially forwarded to CTPS via the Massachusetts Department of Public Works, CTPS has conducted a review of the report entitled, Traffic Impact and Access Study Proposed Office Building Needham, Massachusetts, prepared by the consulting firm of Vanasse/Hangen Associates (V/H). This report details the estimated traffic impact of a proposed general office building to be located at 160 Gould Street in Needham Heights. CTPS was specifically asked to review this report because of the proximity of the proposed facility to, and its possible traffic-generated impact upon, the Highland Avenue/ Needham Street corridor now under study at CTPS.

From a subsequent telephone conversation with Russ Burke, it appeared that Needham was most interested in our comments concerning the following points:

- o whether the traffic conditions at the intersection of Gould Street with Highland Avenue/Hunting Road, which were sampled by V/H during the heart of the summer season, August 13th, 14th, and 15th, were representative of the major portion of the year;
- o whether the trip generation rate used to estimate site-generated vehicular traffic was appropriate to the proposed type of development;
- o whether the method of estimating the distribution/ assignment of those trips as they approached and left the site was reasonable; and
- o whether the conclusion concerning the expected level of service (LOS) at the intersection of Gould Street with Highland Avenue/Hunting Road during the morning peak hour and afternoon peak hour, with the development assumed in place, was reasonable.

We have, therefore, directed our review of the V/H report to these specific points.

Appropriateness of August Traffic Counts

As a general rule there can be a substantial difference in the level of traffic volume at a specific location during the summer vacation months as compared to the remainder of the year. This variation in volume is due to a number of reasons including vacations from work, schools being closed, and increased recreational travel. Each of these factors leads to somewhat conflicting changes in both the total volume of daily traffic and the distribution of that traffic throughout the hours of the day. It is, therefore, reasonable to question the ability of an August count, or any analysis that follows from it, to represent a general condition. In this particular case, it is possible to compare the V/H counts, taken on August 13th, 14th, and 15th, with similar type counts taken by CTPS on September 19th, as part of the Highland Avenue/Needham Street corridor study. This same general argument can also be made concerning representative days of the week, with Tuesday, Wednesday, and Thursday considered the most stable days.

Vanesse/Hangen conducted both automatic traffic recorder (ATR) counts for a 24-hour period (the afternoon of Tuesday, August 14th, and the morning of Wednesday, August 15th) and manual turning movement counts (TMC) for the morning peak (August 14th) and the afternoon peak (Monday, August 13th). The ATR counts were taken by direction on Gould Street just north of its intersection with Highland Avenue and on Highland Avenue just east of Gould Street. The report contains an hourly breakdown of these ATR counts. The TMC were taken for all traffic movements entering along the four legs that comprise the intersection of Gould Street with Highland Avenue/Hunting Road. The V/H report contains only the results of these TMC for the established morning peak hour of demand (7:45-8:45 am) and the similar evening peak hour (5:00-6:00 pm). The results of these V/H counts are compared to each other and to the results of turning movement counts taken by CTPS at the same intersection on Wednesday, September 19th, (as part of the Highland Avenue/Needham Street corridor study) in the following paragraphs.

Figure 1 presents a comparison of the V/H morning count figures taken manually and by machine recorder. Due to limitations in the information contained in the report, the figures derived from the manual counts (TMC) are for the 60-minute period 7:45-8:45 am while the figures from the machine counts (ATR) are for the clock hour 8:00-9:00 am. However, the conclusion drawn should not be significantly affected by this time difference. In all four cases the ATR figure of the pair is less than the TMC figure for that leg. In two cases, southbound on Gould and eastbound on Highland, the difference between the two count sources

Figure 1

Comparison of V/H TMC to V/H ATR Counts
for the Morning Peak Hour

	Gould Street		Gould Street	
Highland	467 (TMC) Tues	Hunting Road	689 (TMC) Tues	1343 (TMC) Tues
	360 (ATR) Wed		666 (ATR) Wed	
Hunting Road				1280 (ATR) Wed
				1626 (TMC) Tues
				1352 (ATR) Wed

Figure 2

Comparison of CTPS TMC to V/H ATR Counts
for 8:00 to 9:00 AM

	Gould Street		Gould Street	
Highland	316 CTPS Wed	Hunting Road	701 CTPS Wed	1161 CTPS Wed
	360 V/H Wed		666 V/H Wed	
Hunting Road				1280 V/H Wed
				1344 CTPS Wed
				1352 V/H Wed

is particularly significant. This is the first piece of evidence that the morning of August 14th was somewhat atypical with traffic volumes tending to the high side.

Further evidence to support this contention is given by the figures shown in Figure 2 where traffic volumes derived from the September CTPS TMC are compared to the V/H ATR figures for the clock hour 8:00-9:00 am. Here, close agreement is shown between the two figures for 3 out of 4 pairs of numbers. Only the westbound Highland Avenue figures, which differ by approximately 10 percent, give any evidence of being different.

Finally, in Figure 3, a comparison is made between the hourly totals derived from the V/H TMC and the CTPS TMC for the 60-minute period falling between 7:45 and 8:45 am. For 7 out of 8 pairs of numbers, the CTPS figure is less than the corresponding V/H figure. In the eighth case, the two numbers are essentially the same value. The overall conclusion to be reached from this analysis is that, for whatever the reason, the morning of August 14th, when the V/H TMC were conducted, seems to have had a higher volume of traffic than normally occurs during the morning peak hour of demand at this location.

Figures 4 through 6 present a similar type of analysis for the afternoon as that just presented for the morning. In Figure 4 the CTPS TMC figures for the hourly period from 5:00-6:00 pm for September 19th are compared to the V/H ATR figures for the same hour taken on August 14th. Close agreement between the pairs of numbers from these two days is shown in 3 out of 4 cases. Only in the case of Highland Avenue eastbound, where the CTPS figure is higher, is there any significant difference between the two figures making up a pair.

When the V/H TMC figures are, instead, compared to these same ATR figures, as is the case in Figure 5, considerably less agreement between the two sources is shown to exist. In 3 out of 4 cases the TMC figure of a pair is less than the corresponding ATR figure and, in one case, it is significantly less. In the fourth case, Gould Street southbound, the two figures are also significantly different, but in the opposite manner with the value of the TMC figure now significantly higher than that of the ATR figure.

In Figure 6 the V/H TMC figures for the hourly period from 5:00 to 6:00 pm are directly compared to the corresponding values derived from the CTPS TMC. When volumes entering the intersection are considered, the V/H value of the pair is less than the corresponding CTPS value in 3 out of 4 cases. Further, in all four cases, including the one case (Gould Street southbound) where the V/H value is the larger of the two numbers, the magnitude of the difference must be considered significant. For volumes exiting the intersection, the CTPS figure is the larger one of the pair in all four cases. Further, the difference in magnitude in two of the cases is certainly significant.

Figure 3

Comparison of V/H TMC to CTPS TMC
for 7:45 to 8:45 AM

782 V/H Tues 631 CTPS Wed	467 V/H Tues 315 CTPS Wed	Gould Street	680 V/H Tues 597 CTPS Wed	1343 V/H Tues 1078 CTPS Wed
Highland			Avenue	
1012 V/H Tues 1015 CTPS Wed	492 V/H Tues 378 CTPS Wed	Hunting Road	758 V/H Tues 599 CTPS Wed	1626 V/H Tues 1401 CTPS Wed

Figure 4

Comparison of CTPS TMC to V/H ATR
for 5:00 to 6:00 PM

Hunting Road	714 CTPS Wed 688 V/H Tues	Gould Street	354 CTPS Wed 334 V/H Tues	1695 CTPS Wed 1463 V/H Tues
	Highland	Avenue	1194 CTPS Wed 1179 V/H Tues	

Figure 5

Comparison of V/H TMC to V/H ATR
for 5:00 to 6:00 PM

ATR figures in ()

Highland	838 V/H Mon (688) V/H Tues	Gould Street	316 V/H Mon (334) V/H Tues	1414 V/H Mon (1463) V/H Tues
		Hunting Road		1045 V/H Mon (1179) V/H Tues
			Avenue	

Figure 6

Comparison of V/H TMC to CTPS TMC
for 5:00 to 6:00 PM

Highland	998 V/H Mon 1146 CTPS Wed	838 V/H Mon 714 CTPS Wed	Gould Street	316 V/H Mon 354 CTPS Wed	1414 V/H Mon 1695 CTPS Wed
	603 V/H Mon 781 CTPS Wed	751 V/H Mon 817 CTPS Wed	Hunting Road	255 V/H Mon 321 CTPS Wed	1045 V/H Mon 1194 CTPS Wed
				Avenue	

In summary, the case seems amply made that traffic flow through the intersection of Gould Street with Highland Avenue/Hunting Road on Monday afternoon, August 13th, and Tuesday morning, August 14th, was significantly different than it may be on more "typical" days of the year. This atypical situation lead to an afternoon result that showed generally less traffic volume than normal and a morning case that showed generally more volume. This is not intuitively what would be expected. Further, the CTPS counts taken on Wednesday, September 19th, showed the more expected results, i.e., the afternoon peak hour more heavily loaded than the morning peak hour.

The V/H TMC results may perhaps be reflective of people creating summer long-weekends that lead to reduced peak-hour travel on the Monday of the week followed by increased travel on Tuesday as people return to a more regular schedule and attempt to catch up on unaccomplished tasks. For whatever the reason this occurred, the results do speak for themselves.

Appropriateness of the Trip Generation Rate

The Institute of Transportation Engineer's Informational Report entitled, Trip Generation, acts as a "bible" for the traffic engineering profession. Therefore, its selection as the source document by V/H is certainly appropriate. As for the selection of Land Use Code 712, General Office/gross floor area between 100,000 and 199,999 square feet, as the appropriate use code, it also seems quite appropriate for a proposed office structure of 170,000 gross square feet, if the specific use, or mix of office uses in a mixed use structure, is not known. Given that, the selection of a trip generation rate of 14.3 vehicular trip ends per 1000 square feet, leading to an estimate of 2,430 daily vehicle trip ends generated at the site by the proposed development, represents an "average condition" for a general office structure of the proposed magnitude. The use of an "average rate" figure would also appear appropriate for this analysis, given that little in the way of specifics appears to be known about the tenants of the site. However, since the ITE report provides maximum and minimum observed rates as well as the average rate, it would be wise as well to provide a "worst case" situation based upon the maximum rate figure. In this case the rate would be 23.6 vehicle trip ends per 1,000 square feet of gross floor area, or 4,012 vehicle trip ends associated with the site on a daily basis. In this way both the higher "worst case" and the much more likely "average case" of potential trip generation impact would consciencely be recognized and explicitly considered.

The morning peak hour and evening peak hour trip generation rates used by V/H are not explicitly identified in their report. However, based upon the vehicle trip figures estimated to enter and to exit the site during these two hours, the average total (nondirectional) trip rate for Code 712 from the ITE report must have been used, i.e., 2.00 vehicle trips and 2.03 vehicle trips for the morning and afternoon peak hour, respectively. This com-

bined value must have then been split into entering and exiting trip components based upon percentages derived from the average entering and exiting trip rates provided in the ITE report.

Again the estimation of an "average condition" for the morning and afternoon peak hours, based upon average trip generation factors, seems reasonable. However, the same argument can again be made for a conscience examination of a "worst case" peak hour scenario as well.

Appropriateness of the Trip Distribution/Assignment Procedure

The distribution/assignment procedure for trips approaching or leaving the proposed development site can be thought of as composed of two components. The first of these components is the proportion (amount) of traffic that will enter/exit the site along Gould Street from the north versus from the south. The second component is then the split of northern-oriented trips to eastbound and westbound along Central Avenue and southern-oriented trips to eastbound and westbound along Highland Avenue and further northbound/southbound along Hunting Road.

The V/H report states that 65 percent of site-introduced traffic will come from/go to the south and the remaining 35 to/from the north. While the derivation of these figures is not presented within the report, the percentages are consistent with the split of traffic shown as travelling northbound and southbound on Gould Street at the proposed site in the No-Build Case. The split is also intuitively appealing as the southern approach contains the influence of Route 128 via Interchange #56 at Highland Avenue and Interchange #57 at Great Plain Avenue.

The manner in which site-introduced traffic is assigned to roadways leading to or from Gould Street is somewhat more complex. The northern-oriented traffic -- traffic which passes through the intersections of Gould Street with Noanett Street and Gould Street with Central Avenue -- appears to be assigned approximately in proportion to existing traffic flows at these intersections. Traffic bound to the site enters along both Noanett Street and from eastbound and westbound on Central Avenue. (There appears to be an error in Figure 4, where 39 not 29 site-introduced trips turn left to Gould Street from Central Avenue westbound.) Traffic bound from the site, however, is assumed to exit along only Gould Street to Central Avenue, where it splits eastbound and westbound. This assignment does not appear consistent with the V/H finding (pages 40-42, Cut-Through Traffic) that some evening traffic entering Noanett Street from Gould Street did pass through the Noanett Street/Central Avenue intersection, but that none travelled in the opposite direction from Central Avenue to Gould street via Noanett Street.

The derivation of the routing of southern-oriented traffic -- traffic which passes through the intersection of Gould Street

with Highland Avenue and Hunting Road -- is rather more mysterious. This traffic is not assigned to turning movements at Highland Avenue in any direct relationship to existing turning movements as is implied in the V/H report.

In a supplemental memorandum to Russell Burke (Needham Planning Director) dated December 12, 1984, V/H states that:

Trips at this intersection (Highland Avenue at Gould Street/Hunting Road) were distributed/assigned based on PM Peak Hour intersection approach volumes for Highland Avenue EB (27%), Highland Avenue WB (62%), and Hunting Road (11%).

The reason for selecting this distribution was further stated to be:

It was felt that the evening peak hour percentages accurately account for the presence of Route 128/I-95 and best represents the anticipated employee distribution of site generated traffic.

This decision meant that percentages derived from traffic volumes observed during the evening peak hour, traffic comprised principally of people making the return-home portion of a trip, were used to represent (model) both morning and evening conditions. More importantly, the site introduced traffic being modelled is approaching the work site not the home site as occurs at this location in the evening. Even beyond this fact, while the total leg volumes approaching one leg of an intersection on the other legs of that intersection may serve as surrogates for the turning volumes from these other legs that act as the true sources of exiting volume on that one leg, if and when these turning volumes are not known, this is not the present case. The appropriate turning movements are known for both the morning and the afternoon peak hours. In a percentage form, they could have been directly put to use. Finally, and perhaps most importantly, the area in which the proposed site is located already contains significant employment attractions. The area along Gould Street, consistent with an employment center, imports trips in the morning and exports trips in the afternoon. (While this fact is in conflict with the statement on page 15, Traffic Volumes, that "directional split of peak hour traffic on Gould Street is 65 percent southbound in the morning and 67 percent northbound in the evening" [underlining added for emphasis], it is consistent with the directionality shown in both the V/H and CTPS counts.) Therefore, in fact, there was no need to modify the existing travel pattern, as might have been the case if a totally new land-use was being introduced into the area.

Due to the series of questions raised above, CTPS prepared an alternative distribution/assignment of southern oriented site-introduced traffic as it approached/departed the site. This alternative distribution/assignment is based directly upon the

Table 1

Comparison of Turning Percentages Derived from V/H and CTPS Counts
To Gould Street

	<u>AM (7:45-8:45)</u>		<u>PM (5:00-6:00)</u>	
	<u>V/H</u>	<u>CTPS</u>	<u>V/H</u>	<u>CTPS</u>
Left from Highland EB	8	11	16	8
Straight from Hunting NB	48	45	24	30
Right from Highland WB	44	44	60	62

From Gould Street

	<u>AM (7:45-8:45)</u>		<u>PM (5:00-6:00)</u>	
	<u>V/H</u>	<u>CTPS</u>	<u>V/H</u>	<u>CTPS</u>
Right to Highland WB	8	9	9	9
Straight to Hunting SB	29	20	46	48
Left to Highland EB	63	71	45	43

Table 2

Turning Percentages Used for Site-Introduced Traffic by V/H
To Gould Street

	<u>AM</u>	<u>PM</u>
Left from Highland EB	26	26
Straight from Hunting NB	11	11
Right from Highland WB	63	63

From Gould Street

	<u>AM</u>	<u>PM</u>
Right to Highland WB	25	26
Straight to Hunting SB	12	11
Left to Highland EB	63	63

turning percentages inherently contained in our September turning movement counts at the Gould Street/Highland Avenue/Hunting Road intersection. These turning movement percentages, together with corresponding ones from the V/H August counts, are presented in Table 1. As can be easily seen, there is very little to choose from between these two sets of percentages, but both sets are significantly different from those percentages, shown in Table 2, that were used by V/H.

The distribution of southern-oriented traffic through the Gould Street intersection with Highland Avenue and Hunting Road under both the V/H and CTPS assumptions is presented in Table 3. While all movements differ in magnitude, the major variation between the V/H and the CTPS distribution/assignment of trips is in the interchanges to and from Hunting Road. In all cases this is the least significant V/H movement. In contrast, the CTPS assignment shows this movement as the most significant of the three from Gould Street in the afternoon and the second most significant movement in all other cases.

Table 3

Distribution/Assignment of Southern-oriented
Site-Introduced Traffic
V/H versus CTPS

To Gould Street

	AM		PM	
	V/H	CTPS	V/H	CTPS
Left from Highland EB	52	28	12	4
Straight from Hunting NB	21	78	5	14
Right from Highland WB	125	92	29	28
Total	198	198	46	46

From Gould Street

	AM		PM	
	V/H	CTPS	V/H	CTPS
Right to Highland WB	6	2	47	16
Straight to Hunting SB	3	5	19	86
Left to Highland EB	15	17	113	77
Total	24	24	179	179

In summary, while the north/south split (35/65) of site-introduced traffic made by V/H seems appropriate, the assignment of that traffic as it leaves Gould Street, particularly at the southern end, does not seem reasonable. For this reason, CTPS has chosen to continue by using both our own and the V/H assignment of site-introduced traffic through the Gould Street/Highland Avenue/Hunting Road intersection in the level of service (LOS) analysis portion of this critique.

Appropriateness of the Level of Service Conclusions

The V/H report indicates that the intersection level of service analysis for signalized intersections, such as Gould Street at Highland Avenue/Hunting Road, was carried out using the Planning application of Critical Movement Analysis as defined in TRB Circular Number 212. As stated in Circular #212, the Planning application of Critical Movement Analysis is based on average or better conditions of geometry and traffic. As such, the planning application provides quick and more simplified solutions. Circular #212 also provides a second methodology for conducting Critical Movement Analysis that is entitled Operations and Design. Again paraphrasing Circular #212, the Operations and Design application of Critical Movement Analysis allows for specific adjustments to be made for traffic and roadway conditions. As such, the Operations and Design application provides for more complex and detailed solutions than does the Planning application.

Because conditions are explicitly considered in the Operations and Design methodology that are only implicitly considered in the Planning methodology, it is the judgment of CTPS that Operations and Design is the more appropriate of the two methodologies, if and when all the required data inputs for an Operations and Design application are available. As this is the case, the level of service analysis conducted by CTPS employed that methodology. In order to make our results directly comparable with those of V/H, we also repeated the V/H analysis employing the Operations and Design approach. Worksheets produced from our computerized application of this methodology are contained in Appendix A.

In order to establish benchmark conditions, the V/H August turning movement volumes and the CTPS September turning movement volumes were used to estimate a level of service for the Gould Street/Highland Avenue/Hunting Road intersection under those demand levels. The results of these analyses for the morning and afternoon peak hours of demand are shown in the upper portion of Table 4. As can be quickly seen, the intersection analysis based upon the V/H and CTPS turning movement counts produces different levels of service for the morning and the afternoon. Beyond this difference is the fact that the analysis based upon the V/H counts shows the morning to be more critical than the afternoon while the analysis based upon the CTPS counts shows just the opposite. However, in neither case does the intersection "fail" as was the case reported by V/H for the morning using the Planning methodology.

In the lower portion of Table 4, the LOS results for four combinations of turning movement counts (expanded from 1984 to 1985) and assumed site-introduced traffic distributions are presented. When the factored V/H turning movement counts are used to model background traffic, the morning is, as might be

Table 4

Level of Service Analysis
Intersection of Gould Street with Highland Avenue and Hunting Road
Operations and Design Methodology

Scenario	Morning Peak Hour		Afternoon Peak Hour	
	LOS	V/C	LOS	V/C
V/H, August 1984	E	0.89	C	0.73
CTPS, September 1984	C	0.69	D	0.82
V/H Counts/V/H Trip Dist	E	0.94	D	0.83
V/H Counts/CTPS Trip Dist	E	0.93	D	0.85
CTPS Counts/V/H Trip Dist	D	0.79	E	0.91
CTPS Counts/CTPS Trip Dist	D	0.79	E	0.91

expected, the more critical. However, the intersection still does not "fail" when either the V/H-assumed or CTPS-assumed distribution of site-introduced traffic is superimposed on that background traffic. When the factored CTPS turning movement volumes are instead used to represent background traffic, the afternoon, expectedly, becomes the more critical time. However, here again the intersection does not "fail" when either the V/H-assumed or CTPS-assumed distribution of site-introduced traffic is superimposed.

Overall Assessment of the Conclusions of the Site Impact Analysis

Questions concerning several areas of the V/H analysis have been raised during our review. Among these are:

- o the selection of a Monday afternoon/Tuesday morning in August as appropriate for conducting a survey of existing traffic for establishing background traffic levels;
- o the method used to distribute/assign southern-oriented traffic at the intersection of Gould Street with Highland Avenue/Hunting Road; and
- o the use of the TRB Circular #212 Planning methodology instead of the Operations and Design methodology for conducting the level of service (LOS) analysis.

We feel that each of these areas is deserving of constructive criticism. However, the bottom line, based upon both the V/H inputs and our own inputs, is that the most critical intersection, Gould Street at Highland Avenue/Hunting Road, while heavily loaded, will continue to operate satisfactorily, i.e., will not fail, despite the introduction of the additional site-generated traffic associated with the proposed 160 Gould Street development.

APPENDIX A

Level of Service (LOS) Analysis Worksheets

Prepared by CTPS
Using
Operations and Design Methodology
(TRB Circular Number 212)
for

- o AM 8/84 V/H TMC
- o PM 8/84 V/H TMC
- o AM 9/84 (CTPS TMC)
- o PM 9/84 (CTPS TMC)
- o AM V/H TMC, V/H Distribution
- o PM V/H TMC, V/H Distribution
- o AM V/H TMC, CTPS Distribution
- o PM V/H TMC, CTPS Distribution
- o AM CTPS TMC, V/H Distribution
- o PM CTPS TMC, V/H Distribution
- o AM CTPS TMC, CTPS Distribution
- o PM CTPS TMC, CTPS Distribution

AM 8/84 VVA TMD

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Gould St.	Hunting Rd.
THRU LANES	2	2	2	2
AVG WIDTH	12	12	11	8
LT LANES	1	1	0	0
AVG WIDTH	10	10	0	0
RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	52	350	294	51
THRU VOL	952	692	134	327
RT VOL	8	301	39	0
PED VOL	0	0	0	0
TRUCK %	3.0	4.4	6.3	1.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	85	85	85	85
CHANGE INT	42	42	42	42
LT CAP ON CI	85	85	85	85
OP VOL	993	960	327	173
LT CAP ON GR	0	0	45	199
LT TOT CAP	85	85	130	284
LT VOL	52	350	294	51
PASS CHK	t	f	f	t

STEP SIX OUTPUT

	1	2	3	4
PHE	0.90	0.90	0.90	0.90
LT VOL	60	406	347	58
THRU VOL	1090	803	158	369
RT VOL	9	349	46	0

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	993	960	327	173
PCE LTU	4.00	4.00	2.00	1.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

UNPROTECT LT

PROTECT LT

S2	238	62
S1	1099	1099
S1	1624	426
A2	1152	1152
A3B4	899	621
A4B3	426	438

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
82	238	62
81	577	577
81	1624	426
42	605	605
42B4	472	326
44B3	246	253

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

1624	1-one phase only
1031	2-two phase,one left protected,no overlap
1003	3-two phases,one left protected,overlap
1031	4-two phases,both lefts protected,no overlap
1003	5-three phases,both lefts protected,overlap
1094	6-three phases,lead/lag,no overlap
2201	7-three phases,lead/lag,overlap
1182	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

472	1-one phase only
579	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
3	1*	0.86	1475	1720	D
2	1*	0.87	1503	1720	D
4	1*	0.87	1503	1720	D
5	1*	0.89	1475	1650	E
6	1*	0.95	1565	1650	E
5	8	0.96	1582	1650	E
3	8	0.96	1582	1650	E
8	1*	0.96	1653	1720	E
2	8	0.98	1610	1650	E
4	8	0.98	1610	1650	E
6	8	1.01	1672	1650	F
8	8	1.07	1760	1650	F
1*	1*	1.16	2096.	1800	F
1*	8	1.28	2203	1720	F
7	1*	1.62	2673	1650	F
7	8	1.68	2780	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above

CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

PM 8/84 V/H TMC

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Gould St.	Hunting Rd.
#THRU LANES	2	2	2	2
AVG WIDTH	12	12	11	8
#LT LANES	1	1	0	0
AVG WIDTH	10	10	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	51	326	379	25
THRU VOL	512	899	385	76
RT VOL	40	189	74	0
PED VOL	0	0	0	0
TRUCK %	2.1	2.1	1.2	1.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE (secs)	85	85	85	85
CHANGE INT	42	42	42	42
LT CAP ON CI	85	85	85	85
G/C	.56	.56	.43	.43
OP VOL	1088	552	76	459
LT CAP ON GR	0	120	440	57
LT TOT CAP	85	205	525	142
RT VOL	51	326	379	25
PASS CHK	t	f	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.90	0.90	0.90	0.90
LT VOL	58	370	426	28
THRU VOL	581	1020	433	86
RT VOL	45	214	83	0

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	1088	552	76	459
PCE LTU	6.00	2.00	1.00	2.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

UNPROTECT LT PROTECT LT

B2	347	61
A1	626	626
B1	740	388
A2	1234	1234
B3B4	942	1028
A3B3	142	120

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B2	347	61
B1	329	329
B1	740	388
A2	648	648
A3B4	495	539
A4B3	82	69

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

740	1-one phase only
1036	2-two phase,one left protected,no overlap
735	3-two phases,one left protected,overlap
1036	4-two phases,both lefts protected,no overlap
717	5-three phases,both lefts protected,overlap
1097	6-three phases,lead/lag,no overlap
1087	7-three phases,lead/lag,overlap
977	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

495	1-one phase only
608	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1*	1	0.69	1234	1800	C
3	1	0.72	1230	1720	C
5	1	0.73	1212	1650	C
1*	8	0.78	1348	1720	D
5	8	0.80	1326	1650	D
3	8	0.81	1344	1650	D
8	1	0.86	1471	1720	D
2	1	0.89	1531	1720	E
4	1	0.89	1531	1720	E
7	1	0.96	1581	1650	E
8	8	0.96	1585	1650	E
6	1	0.96	1592	1650	E
2	8	1.00	1645	1650	E
4	8	1.00	1645	1650	E
7	8	1.03	1695	1650	F
6	8	1.03	1706	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above

CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

AM 9/84 ASSUME ELIMINATION OF HUNTING RD RIGHT TURN EFFECTS

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Gould St.	Hunting Rd.
THRU LANES	2	2	2	2
AVG WIDTH	12	12	11	8
LT LANES	1	1	0	0
AVG WIDTH	10	10	0	0
RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	100	318	222	67
THRU VOL	855	517	67	275
RT VOL	29	326	27	0
PED VOL	5	5	5	5
TRUCK %	3.3	4.4	6.3	1.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

CYCLE(secs)	85	85	85	85
CHANGE INT	42	42	42	42
LT CAP ON CI	85	85	85	85
G/C	.72	.72	.27	.27
OP VOL	843	884	275	94
LT CAP ON GR	21	0	49	230
LT TOT CAP	106	85	134	315
LT VOL	100	318	222	67
PASS CHK	t	f	f	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.92	0.87	0.93	0.91
LT VOL	112	382	254	75
THRU VOL	960	620	77	307
RT VOL	33	391	31	0

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	843	884	275	94
PCE LTU	4.00	4.00	1.00	1.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

UNPROTECT LT PROTECT LT

S2	449	118
A1	993	993
B1	1526	401
A2	1012	1012
A3B4	361	412
A4B3	381	396

STEP EIGHT AND NINE A OUTPUT

UNPROTECT LT PROTECT LT

UNPROTECT LT PROTECT LT

B2	449	118
A1	521	521
B1	1526	401
A2	531	531
A3B4	190	216
A4B3	220	229

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

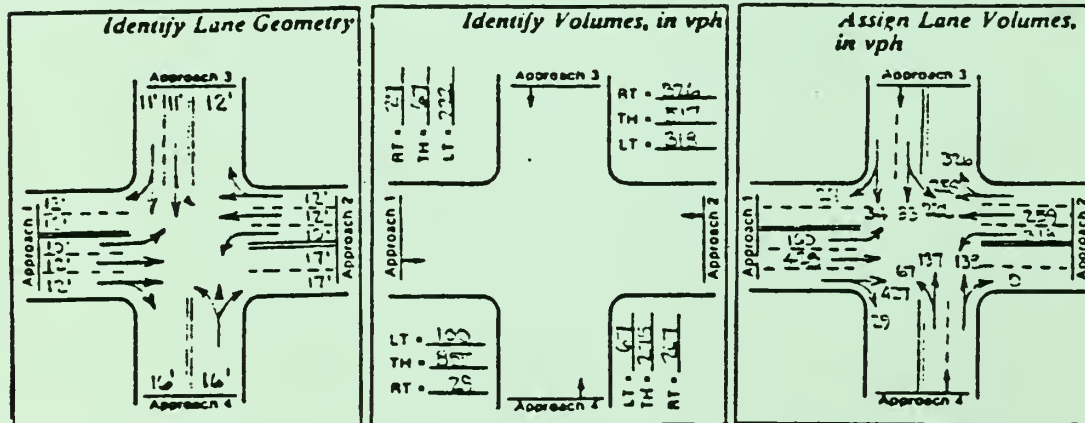
1526	1-one phase only
932	2-two phase,one left protected,no overlap
922	3-two phases,one left protected,overlap
932	4-two phases,both lefts protected,no overlap
922	5-three phases,both lefts protected,overlap
1050	6-three phases,lead/lag,no overlap
2048	7-three phases,lead/lag,overlap
1052	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

220	1-one phase only
445	9-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
3	1*	0.66	1142	1720	B
2	1*	0.67	1152	1720	B
4	1*	0.67	1152	1720	B
5	1*	0.69	1142	1650	C
8	1*	0.74	1272	1720	C
6	1*	0.77	1270	1650	C
5	8	0.83	1367	1650	D
3	8	0.83	1367	1650	D
4	8	0.83	1377	1650	D
2	8	0.83	1377	1650	D
6	8	0.91	1495	1650	E
8	8	0.91	1497	1650	E
1*	1*	0.97	1742	1800	E
1*	8	1.15	1972	1720	F
7	1*	1.37	2268	1650	F
7	8	1.51	2493	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above



1. CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

PM 9/84 ASSUME ELIMINATION OF HUNTING RD RIGHT TURN EFFECTS

1. STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Gould St.	Hunting Rd.
#THRU LANES	2	2	2	2
AVG WIDTH	12	12	11	8
#LT LANES	1	1	0	0
AVG WIDTH	10	10	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	37	400	317	27
THRU VOL	723	1072	354	114
RT VOL	62	236	67	0
PED VOL	5	5	5	5
TRUCK %	2.1	2.1	1.2	1.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

CYCLE(secs)	85	85	85	85
CHANGE INT	42	42	42	42
LT CAP ON CI	85	85	85	85
G/C	.63	.63	.36	.36
OP VOL	1308	785	114	421
LT CAP ON GR	0	0	318	11
LT TOT CAP	85	85	403	96
LT VOL	37	400	317	27
PASS CHK	t	f	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.90	0.95	0.90	0.84
LT VOL	42	430	356	33
THRU VOL	820	1152	398	138
RT VOL	70	254	75	0

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	1308	785	114	421
PCE LTU	6.00	4.00	1.00	2.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B2	252	44
A1	891	891
B1	1720	451
A2	1406	1406
A3B4	830	901
A4B3	203	177

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B2	252	44
A1	468	468
B1	1720	451
A2	738	738
A3B4	436	473
A4B3	117	102

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

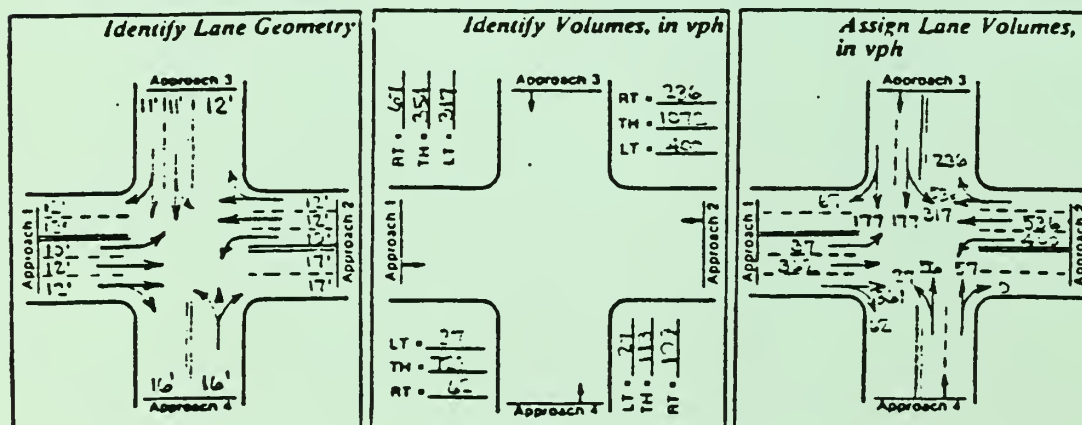
1720	1-one phase only
1189	2-two phase,one left protected,no overlap
919	3-two phases,one left protected,overlap
1189	4-two phases,both lefts protected,no overlap
919	5-three phases,both lefts protected,overlap
1233	6-three phases,lead/lag,no overlap
2187	7-three phases,lead/lag,overlap
1206	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

436	1-one phase only
575	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
3	1	0.79	1355	1720	D
5	1	0.82	1355	1650	D
5	8	0.91	1494	1650	E
3	8	0.91	1494	1650	E
4	1	0.94	1625	1720	E
2	1	0.94	1625	1720	E
8	1	0.95	1641	1720	E
6	1	1.01	1669	1650	F
4	8	1.07	1765	1650	F
2	8	1.07	1765	1650	F
8	8	1.08	1781	1650	F
6	8	1.10	1809	1650	F
1*	1	1.20	2155	1800	F
1*	8	1.33	2295	1720	F
7	1	1.59	2623	1650	F
7	8	1.67	2762	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above



CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

AM V/H AND V/H DISTRIBUTION

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Wald St.	Hunting Hs.
THRU LANES	2	2	2	2
AVE WIDTH	12	12	11	9
LT LANES	1	1	0	0
AVE WIDTH	10	10	0	0
RT LANES	0	0	0	0
AVE WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	106	361	318	57
THRU VOL	981	713	141	358
RT VOL	9	361	46	0
PEB VOL	0	0	0	0
TRUCK %	3.0	4.4	6.3	1.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE (secs)	85	85	65	65
CHANGE INT	42	42	42	42
LT CAP ON CI	85	85	85	85
G/C	.68	.68	.31	.31
OP VOL	1074	989	358	187
LT CAP ON GR	0	0	14	185
LT TOT CAP	85	85	99	370
LT VOL	106	361	318	57
PASS CHK	+	+	+	+

STEP SIX OUTPUT

	1	2	3	4
PHF	0.90	0.90	0.90	0.90
LT VOL	121	419	376	50
THRU VOL	1123	827	167	404
RT VOL	9	419	54	0

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	1074	989	358	187
PCE LTU	6.00	4.00	2.00	1.00
PCE LIP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECTED LT	PROTECTED LT
P2	725	127
A1	1173	1132
P1	1675	440
AC	1244	1246
3254	972	572
4457	464	470

STEP EIGHT AND NINE A OUTPUT

	UNPROTECTED LT	PROTECTED LT
512	128	127
41	894	894
91	1675	440
42	824	854
1094	510	353
4487	168	275

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

1675	1-one phase only
1159	2-two phase,one left protected,no overlap
1168	3-two phases,one left protected,overlap
1094	4-two phases,both lefts protected,no overlap
1034	5-three phases,both lefts protected,overlap
1221	6-three phases,lead/lag,no overlap
2403	7-three phases,lead/lag,overlap
1248	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

510	1-one phase only
627	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
4	1*	0.93	1604	1720	E
5	1*	0.94	1544	1650	E
3*	1*	0.98	1678	1720	E
2*	1*	0.98	1678	1720	E
5	8	1.01	1661	1650	F
8	1*	1.02	1759	1720	F
4	8	1.04	1721	1650	F
6	1*	1.05	1731	1650	F
3*	8	1.09	1795	1650	F
2*	8	1.09	1795	1650	F
6	8	1.12	1848	1650	F
8	8	1.14	1875	1650	F
1*	1*	1.21	2185.	1800	F
1*	8	1.34	2302	1720	F
7	1*	1.77	2913	1650	F
7	8	1.84	3030	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above

CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

PM V/H TMC V/H DISTRIBUTION

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Gould St.	Hunting Rd.
#THRU LANES	2	2	2	2
AVG WIDTH	12	12	11	8
#LT LANES	1	1	0	0
AVG WIDTH	10	10	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	65	336	503	26
THRU VOL	527	926	416	83
RT VOL	41	224	123	0
RED VOL	0	0	0	0
TRUCK %	2.1	2.1	1.2	1.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	85	85	85	85
CHANGE INT	42	42	42	42
LT CAP ON CI	85	85	85	85
S/C	.52	.52	.47	.47
OP VOL	1150	568	83	539
LT CAP ON GR	0	56	481	25
LT TOT CAP	85	141	566	110
LT VOL	65	336	503	26
PASS CHK	t	f	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.90	0.90	0.90	0.90
LT VOL	74	381	566	29
THRU VOL	598	1050	468	94
RT VOL	47	254	138	0

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	1150	568	83	539
PCE LTU	6.00	2.00	1.00	2.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
S2	442	77
A1	644	644
S1	762	400
A2	1305	1305
S3B4	1172	1285
A4B3	152	129

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
92	442	77
A1	338	338
B1	762	400
A2	685	685
A3B4	615	675
A4B3	88	74

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

762	1-one phase only
1085	2-two phase,one left protected,no overlap
843	3-two phases,one left protected,overlap
1085	4-two phases,both lefts protected,no overlap
762	5-three phases,both lefts protected,overlap
1163	6-three phases,lead/lag,no overlap
1205	7-three phases,lead/lag,overlap
1023	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

615	1-one phase only
749	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1*	1	0.77	1377	1800	C
5	1	0.83	1377	1650	D
3	1	0.85	1458	1720	D
1*	8	0.88	1511	1720	D
5	8	0.92	1511	1650	E
8	1	0.95	1638	1720	E
3	8	0.96	1592	1650	E
2	1	0.99	1700	1720	E
4	1	0.99	1700	1720	E
8	8	1.07	1772	1650	F
6	1	1.08	1778	1650	F
7	1	1.10	1820	1650	F
2	8	1.11	1834	1650	F
4	8	1.11	1834	1650	F
6	8	1.16	1911	1650	F
7	8	1.18	1954	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above

CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

AM V/H TMC CTPS DISTRIBUTION

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Gould St.	Hunting Rd.
#THRU LANES	2	2	2	2
AVG WIDTH	12	12	11	8
#LT LANES	1	1	0	0
AVG WIDTH	10	10	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	82	361	320	53
THRU VOL	981	713	143	415
RT VOL	8	402	42	0
PED VOL	0	0	0	0
TRUCK %	3.3	4.4	6.3	1.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE (secs)	85	85	85	85
CHANGE INT	42	42	42	42
LT CAP ON CI	85	85	85	85
G/C	.68	.68	.31	.31
OP VOL	1115	989	415	185
LT CAP ON GR	0	0	0	187
LT TOT CAP	85	85	85	272
LT VOL	82	361	320	53
PASS CHK	t	f	f	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.92	0.87	0.93	0.91
LT VOL	92	433	366	59
THRU VOL	1101	856	163	463
RT VOL	9	482	48	0

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	1115	989	415	185
PCE LTU	6.00	4.00	2.00	1.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B2	552	97
A1	1110	1110
B1	1733	455
A2	1338	1338
A3B4	943	650
A4B3	522	534

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B2	552	97
A1	583	583
B1	1733	455
A2	702	702
A3B4	495	341
A4B3	301	308

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

1733	1-one phase only
1157	2-two phase,one left protected,no overlap
1038	3-two phases,one left protected,overlap
1157	4-two phases,both lefts protected,no overlap
1038	5-three phases,both lefts protected,overlap
1254	6-three phases,lead/lag,no overlap
2316	7-three phases,lead/lag,overlap
1285	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

495	1-one phase only
650	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
3	1*	0.89	1533	1720	E
5	1*	0.93	1533	1650	E
4	1*	0.96	1652	1720	E
2	1*	0.96	1652	1720	E
3	8	1.02	1688	1650	F
5	8	1.02	1688	1650	F
8	1*	1.04	1781	1720	F
6	1*	1.06	1749	1650	F
4	8	1.10	1807	1650	F
2	8	1.10	1807	1650	F
6	8	1.15	1904	1650	F
8	8	1.17	1935	1650	F
1*	1*	1.24	2228	1800	F
1*	8	1.39	2383	1720	F
7	1*	1.70	2811	1650	F
7	8	1.80	2966	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above

CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

PM V/H TMC CTPS DISTRIBUTION

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Gould St.	Hunting Rd.
#THRU LANES	2	2	2	2
AVG WIDTH	12	12	11	8
#LT LANES	1	1	0	0
AVG WIDTH	10	10	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	57	336	467	26
THRU VOL	527	926	483	92
RT VOL	41	336	92	0
PED VOL	0	0	0	0
TRUCK %	2.1	2.1	1.2	1.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	85	85	85	85
CHANGE INT	42	42	42	42
LT CAP ON CI	85	85	85	85
G/C	.54	.54	.45	.45
OP VOL	1262	568	92	575
LT CAP ON GR	0	80	448	0
LT TOT CAP	85	165	533	85
LT VOL	57	336	467	26
PASS CHK	t	f	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.90	0.95	0.90	0.84
LT VOL	65	361	525	31
THRU VOL	598	995	543	111
RT VOL	47	361	103	0

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	1262	568	92	575
PCE LTU	6.00	2.00	1.00	2.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B2	388	68
A1	644	644
B1	722	379
A2	1356	1356
A3B4	1172	1277
A4B3	174	149

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B2	389	68
A1	338	338
B1	722	379
A2	712	712
A3B4	615	670
A4B3	100	86

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

722	1-one phase only
1091	2-two phase,one left protected,no overlap
767	3-two phases,one left protected,overlap
1091	4-two phases,both lefts protected,no overlap
780	5-three phases,both lefts protected,overlap
1159	6-three phases,lead/lag,no overlap
1110	7-three phases,lead/lag,overlap
1050	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

615	1-one phase only
756	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
1*	1	0.74	1337	1800	C
3	1	0.80	1382	1720	D
5	1	0.85	1395	1650	D
1*	8	0.86	1478	1720	D
3	8	0.92	1523	1650	E
5	8	0.93	1536	1650	E
8	1	0.97	1665	1720	E
2	1	0.99	1706	1720	E
4	1	0.99	1706	1720	E
7	1	1.05	1725	1650	F
6	1	1.08	1774	1650	F
8	8	1.09	1807	1650	F
2	8	1.12	1847	1650	F
4	8	1.12	1847	1650	F
7	8	1.13	1866	1650	F
6	8	1.16	1915	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above

CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

AM CTPS TMC V/H DISTRIBUTION

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Gould St.	Hunting Rd.
#THRU LANES	2	2	2	2
AVG WIDTH	12	12	11	8
#LT LANES	1	1	0	0
AVG WIDTH	10	10	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	155	328	244	69
THRU VOL	881	532	72	304
RT VOL	30	461	34	0
PED VOL	0	0	0	0
TRUCK %	3.3	4.4	6.3	1.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE (secs)	85	85	85	85
CHANGE INT	42	42	42	42
LT CAP ON CI	85	85	85	85
G/C	.72	.72	.27	.27
OP VOL	993	911	304	106
LT CAP ON GR	0	0	20	218
LT TOT CAP	85	85	105	303
LT VOL	155	328	244	69
PASS CHK	f	f	f	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.92	0.87	0.93	0.91
LT VOL	174	394	279	77
THRU VOL	989	638	82	339
RT VOL	34	553	39	0

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	993	911	304	106
PCE LTU	4.00	4.00	2.00	1.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B2	696	183
A1	1023	1023
B1	1574	413
A2	1192	1192
A3B4	679	456
A4B3	416	431

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B2	696	183
A1	537	537
B1	1574	413
A2	626	626
A3B4	356	239
A4B3	240	249

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

1574	1-one phase only
1109	2-two phase,one left protected,no overlap
1109	3-two phases,one left protected,overlap
1039	4-two phases,both lefts protected,no overlap
950	5-three phases,both lefts protected,overlap
1222	6-three phases,lead/lag,no overlap
2271	7-three phases,lead/lag,overlap
1163	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

356	1-one phase only
488	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
5	1*	0.79	1307	1650	D
4	1*	0.81	1395	1720	D
3*	1*	0.85	1466	1720	D
2*	1*	0.85	1466	1720	D
5	8	0.87	1439	1650	D
8	1*	0.88	1519	1720	D
4	8	0.93	1527	1650	E
6	1*	0.96	1578	1650	E
3*	8	0.97	1598	1650	E
2*	8	0.97	1598	1650	E
8	8	1.00	1651	1650	F
6	8	1.04	1710	1650	F
1*	1*	1.07	1931	1800	F
1*	8	1.20	2063	1720	F
7	1*	1.59	2627	1650	F
7	8	1.67	2759	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above

CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

PM CTPS TMC V/H DISTRIBUTION

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Gould St.	Hunting Rd.
#THRU LANES	2	2	2	2
AVG WIDTH	12	12	11	8
#LT LANES	1	1	0	0
AVG WIDTH	10	10	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	50	412	439	28
THRU VOL	745	1104	384	121
RT VOL	64	272	116	0
PED VOL	0	0	0	0
TRUCK %	2.1	2.1	1.2	1.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	85	85	85	85
CHANGE INT	42	42	42	42
LT CAP ON CI	85	85	85	85
G/C	.59	.59	.40	.40
OP VOL	1376	809	121	500
LT CAP ON GR	0	0	359	0
LT TOT CAP	85	85	444	85
LT VOL	50	412	439	28
PASS CHK	t	f	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.90	0.95	0.90	0.84
LT VOL	57	443	494	34
THRU VOL	845	1187	432	146
RT VOL	73	292	130	0

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	1376	809	121	500
PCE LTU	6.00	4.00	1.00	2.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B2	340	60
A1	918	918
B1	1771	465
A2	1479	1479
A3B4	1056	1155
A4B3	214	187

STEP EIGHT AND NINE OUTPUT

	UNPROTECT LT	PROTECT LT
B2	340	60
A1	482	482
B1	1771	465
A2	776	776
A3B4	554	606
A4B3	124	108

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

1771	1-one phase only
1241	2-two phase,one left protected,no overlap
947	3-two phases,one left protected,overlap
1241	4-two phases,both lefts protected,no overlap
947	5-three phases,both lefts protected,overlap
1301	6-three phases,lead/lag,no overlap
2253	7-three phases,lead/lag,overlap
1258	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

554	1-one phase only
714	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
3	1	0.87	1501	1720	D
5	1	0.91	1501	1650	E
5	8	1.01	1661	1650	F
3	8	1.01	1661	1650	F
4	1	1.04	1796	1720	F
2	1	1.04	1796	1720	F
8	1	1.05	1813	1720	F
6	1	1.12	1855	1650	F
4	8	1.19	1955	1650	F
2	8	1.19	1955	1650	F
8	8	1.20	1972	1650	F
6	8	1.22	2015	1650	F
1*	1	1.29	2325	1800	F
1*	8	1.44	2485	1720	F
7	1	1.70	2807	1650	F
7	8	1.80	2967	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above

CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

AM CTPS TMC CTPS DISTRIBUTION

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Gould St.	Hunting Rd.
#THRU LANES	2	2	2	2
AVG WIDTH	12	12	11	8
#LT LANES	1	1	0	0
AVG WIDTH	10	10	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	131	328	246	69
THRU VOL	881	532	74	361
RT VOL	30	428	30	0
PED VOL	0	0	0	0
TRUCK %	3.3	4.4	6.3	1.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	85	85	85	85
CHANGE INT	42	42	42	42
LT CAP ON CI	85	85	85	85
G/C	.69	.69	.30	.30
OP VOL	960	911	361	104
LT CAP ON GR	0	0	0	256
LT TOT CAP	85	85	85	341
LT VOL	131	328	246	69
PASS CHK	f	f	f	t

STEP SIX OUTPUT

	1	2	3	4
FHF	0.92	0.87	0.93	0.91
LT VOL	147	394	281	77
THRU VOL	989	638	85	403
RT VOL	34	514	34	0

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	960	911	361	104
PCE LTU	4.00	4.00	2.00	1.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B2	588	154
A1	1023	1023
B1	1574	413
A2	1152	1152
A3B4	681	456
A4B3	480	495

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B2	588	154
A1	537	537
B1	1574	413
A2	605	605
A3B4	358	240
A4B3	277	286

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

1574	1-one phase only
1018	2-two phase,one left protected,no overlap
1002	3-two phases,one left protected,overlap
1018	4-two phases,both lefts protected,no overlap
950	5-three phases,both lefts protected,overlap
1173	6-three phases,lead/lag,no overlap
2163	7-three phases,lead/lag,overlap
1142	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

358	1-one phase only
525	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
3*	1*	0.79	1359	1720	D
5	1*	0.79	1308	1650	D
4	1*	0.80	1376	1720	D
2*	1*	0.80	1376	1720	D
8	1*	0.87	1499	1720	D
5	8	0.89	1476	1650	E
3*	8	0.93	1527	1650	E
6	1*	0.93	1530	1650	E
2*	8	0.94	1543	1650	E
4	8	0.94	1543	1650	E
8	8	1.01	1667	1650	F
6	8	1.03	1698	1650	F
1*	1*	1.07	1932	1800	F
1*	8	1.22	2100	1720	F
7	1*	1.53	2520	1650	F
7	8	1.63	2688	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above

CIRCULAR 212 WORKSHEET: SIGNALIZED INTERSECTION - OPERATIONS & DESIGN

PM CTPS TMC CTPS DISTRIBUTION

STEP ONE OUTPUT

	1	2	3	4
NAME	Highland Ave.	Highland Ave.	Gould St.	Hunting Rd.
#THRU LANES	2	2	2	2
AVG WIDTH	12	12	11	8
#LT LANES	1	1	0	0
AVG WIDTH	10	10	0	0
#RT LANES	0	0	0	0
AVG WIDTH	0	0	0	0

STEP TWO OUTPUT

	1	2	3	4
LT VOL	42	412	403	28
THRU VOL	745	1104	451	130
RT VOL	64	271	85	0
PED VOL	0	0	0	0
TRUCK %	2.1	2.1	1.2	1.5
BUS STOP	0	0	0	0

STEP FOUR OUTPUT

	1	2	3	4
CYCLE(secs)	85	85	85	85
CHANGE INT	42	42	42	42
LT CAP ON CI	85	85	85	85
G/C	.59	.59	.40	.40
OP VOL	1375	809	130	536
LT CAP ON GR	0	0	350	0
LT TOT CAP	85	85	435	85
LT VOL	42	412	403	28
PASS CHK	t	f	t	t

STEP SIX OUTPUT

	1	2	3	4
PHF	0.90	0.95	0.90	0.84
LT VOL	48	443	453	34
THRU VOL	845	1187	507	157
RT VOL	73	291	96	0

STEP SEVEN OUTPUT

	1	2	3	4
OP VOL	1375	809	130	536
PCE LTU	6.00	4.00	1.00	2.00
PCE LTP	1.05	1.05	1.20	1.20
PCE RT	1.00	1.00	1.00	1.00

	UNPROTECT LT	PROTECT LT
B2	286	50
A1	913	913
B1	1771	465
A2	1478	1478
A3B4	1056	1146
A4B3	225	198

STEP EIGHT AND NINE A OUTPUT

	UNPROTECT LT	PROTECT LT
B2	286	50
A1	482	482
B1	1771	465
A2	776	776
A3B4	554	602
A4B3	130	114

STEP TEN OUTPUT

POSSIBLE PHASES APPROACHES 1 & 2

1771	1-one phase only
1241	2-two phase,one left protected,no overlap
947	3-two phases,one left protected,overlap
1241	4-two phases,both lefts protected,no overlap
947	5-three phases,both lefts protected,overlap
1291	6-three phases,lead/lag,no overlap
2253	7-three phases,lead/lag,overlap
1258	8-two phases,directional split

POSSIBLE PHASES APPROACHES 3 & 4

554	1-one phase only
716	8-two phases,directional split

Phasing 1&2	Phasing 3&4	v/c	SUM CV	Capacity	LOS
3	1	0.87	1501	1720	D
5	1	0.91	1501	1650	E
5	8	1.01	1663	1650	F
3	8	1.01	1663	1650	F
4	1	1.04	1795	1720	F
2	1	1.04	1795	1720	F
8	1	1.05	1812	1720	F
6	1	1.12	1845	1650	F
4	8	1.19	1957	1650	F
2	8	1.19	1957	1650	F
8	8	1.20	1974	1650	F
6	8	1.22	2007	1650	F
1*	1	1.29	2325	1800	F
1*	8	1.45	2487	1720	F
7	1	1.70	2807	1650	F
7	8	1.80	2969	1650	F

* This phasing may be inappropriate due to left turn restrictions
see STEP FOUR OUTPUT above



NEWTON-NEEDHAM

CHAMBER OF COMMERCE, INC.

437 CHERRY STREET • NEWTON, MASSACHUSETTS • 02188

AREA CODE 617 • 244-5300

June 12, 1985

Robert T. Tierney, Commissioner
Massachusetts Department of Public Works
10 Park Plaza
Boston, Massachusetts 02116

Dear Commissioner Tierney:

I am writing to you to seek an update on progress toward resolving the ongoing problems in the Highland Ave.-Needham Street Corridor.

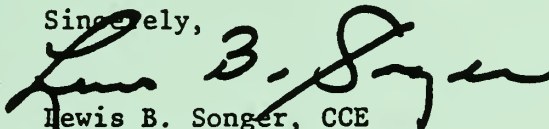
It is our understanding that the Central Transportation Planning Staff report has been in various stages of completion for some time now and yet it has not been issued.

What are the major problems which are delaying its completion? Are there policy differences which remain unresolved? Can we help?

I can assure you that the problems in the Corridor are steadily increasing and once the ease of summer is over, we can look forward only to increased congestion and traffic delays. Taxi drivers, for example, are avoiding the area and utilizing routes through residential neighborhoods. Other drivers are doing the same, including trucks.

We ask you to please give this matter your personal attention. We look forward to working with your department to ease the situation, but we need to know just where the progress is at this point.

Sincerely,


Lewis B. Songer, CCE
Executive Vice President

LBS/ho

cc: Mayor Mann
Selectman Chairman Garrity
Barry Canner
John Cogswell
Richard Gagney





NEWTON-NEEDHAM

CHAMBER OF COMMERCE, INC.

437 CHERRY STREET • NEWTON, MASSACHUSETTS • 02165

AREA CODE 617 • 244-5300

LEWIS B. SONGER, CCE
Executive Vice President

October 3, 1985

Special Meeting: Highland Ave.-Needham Street Task Force

**7:45 a.m. Honeywell Information Systems
141 Needham Street
Newton Highlands**

There will be a special meeting of the Highland Ave.-Needham Street Task Force on Thursday, October 17th at 7:45 a.m. at Honeywell Information Systems, 141 Needham Street, Newton Highlands.

Participants will include members of the Chamber's task force as well as representatives of the state Department of Public Works, the Central Transportation Planning Staff of the state, Needham and Newton Planning and Engineering officials.

The status of the project and the necessary reports and reviews will be discussed.

Please call the Chamber office to indicate your attendance plans.

John Fox, Chairman





NEWTON-NEEDHAM

CHAMBER OF COMMERCE, INC.

437 CHERRY STREET • NEWTON, MASSACHUSETTS • 02165

LEWIS B. SONGER, CCE
Executive Vice President

AREA CODE 617 • 244-5300

February 3, 1986

Mr. Lawrence H. Tittlemore
Central Transportation Planning Staff
State Transportation Building
10 Park Plaza, Suite 2150
Boston, Massachusetts 02116

Dear Larry:

I am writing on behalf of the technical advisory committee members (enumerated at the end of the letter) in response to our meeting with you and other state officials on Jan. 9th.

We wish to comment on the "Existing Conditions" draft report and presentation made to us at your offices by you and Bill Steffens.

With respect to the overall report we found that it describes the land uses and the present situation very well. It defines the problems accurately and reflects technical competence at a high level of analysis. Finally, it is very well written and easy to understand. Your presentation orally and the visual presentation and choice of graphics was very well done, too.

As an overall statement before we address the particulars, we should clearly state that the omission of the frontage road parallel to Route 128 needs to be corrected because without the frontage road there can be no long-term solutions to the problems for the corridor. There simply must be ways to enter the industrial park from Highland Avenue besides Second Avenue and the limited entry at First Avenue.

A) We are in agreement on several of your short-run recommendations:

1. That the installation of traffic lights at the Oak/Christina and Winchester/Dedham/Needham Streets intersections should proceed.
2. There is a need for coordinating the timing of the Oak/Christina light with the Second Avenue light.
3. That Needham Street be re-stripped for three lanes to allow for left-turn movements.
4. That the median strip at First Avenue NOT be removed in the short run.
5. That the 5 lane configuration on Highland Avenue allow for a third lane westbound (continuous) to allow for southbound turns into Second Avenue.

(continued)



cc
M. J. J. J.

B) We would suggest modifications on the following issues:

1. That the suggested improvements for Third and Fourth Avenue intersections with Kendrick Street proceed with the lane markings. The concept of one-way streets is not feasible because they cannot be connected by extending B Street without a major land taking. The possibility of lights at 4th and/or 3rd should be considered, also.
2. That the suggested left turn lane eastbound on Highland Avenue in the vicinity of Charles and Wexford Streets be limited to left turns only into Charles Street, because there so many more businesses north of Highland Avenue. This change would be predicated on continuing Charles Street as a two-way street and making Wexford Street a "Do Not Enter" street from Highland Avenue and requiring all traffic leaving Wexford Street be limited to right turn only toward Route 128.

This essentially captures the same concept as you suggest for Third and Fourth Avenue and would allow some stacking in the left turn lane eastbound without impeding other traffic eastbound. It could be done as a "pilot" program and if found to be unworkable, it could be abandoned.

3. We think further consideration needs to be given to the Floral Street/ramp connection recommendation (including considering making Floral Street two ways) to avoid trapping the apartment house residents.

C) We do not agree that:

1. In the short-run the jug handle solution is practical because of the land-takings that would be necessary.
2. We are also concerned about the suggested road to connect at the base of the hill with Second Avenue because it is too close to the intersection. Traffic would block Second Avenue southbound in trying to "get into line" on Second Avenue northbound. The very recent major and ongoing construction practically negates this possibility. Again the practicality involved in land-taking is not short-run. We do not agree that the bridge may not become, if it is not now, a bottleneck.

D) Also, we would like to suggest the following:

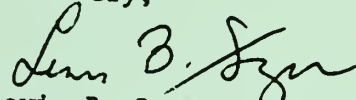
1. That the restriction right-turn-on red be removed at Second Avenue-Highland Avenue, thus creating a "release" in northbound Second Avenue backups.
2. That the entire program keep in mind that the impending opening of the Hillside Office building and the proposed opening of the Sheraton Hotel next Fall will have a substantial impact on area traffic and consideration be given to method of evaluating this impact.

We wish to emphasize the importance of accomplishing the re-stripping, lane designation, signage and turn restriction during the 1986 construction season and that every effort be made to assure that the final design, bidding and installation of the practical and orderly timetable be established for this key element in the plan.

We are concerned about the timing and sequence of the final report. Would we be correct in assuming that you will issue your final report by March 15? If so, it is important for us to arrange a meeting for a formal presentation to city and town officials as soon thereafter as possible.

Thank you for the opportunity to continue our work with you.

Sincerely,



Lewis B. Songer, CCE
Executive Vice President
(for the committee:)

LBS/ho

cc: Lewis Branzburg
Barry Canner
Calvin Cook
John Fox
Paul Giunta
Roy LaMotte
John Marr
Richard Robinson

April 7, 1986

Mr. Lewis Songer, CCE
Executive Vice President
Newton-Needham Chamber of Commerce, Inc.
437 Cherry Street
Newton, MA 02165

Dear Lew:

I would like to thank you for your letter on behalf of the Newton, Needham and Chamber of Commerce members of the Highland Avenue-Needham Street Technical Advisory Committee (TAC) containing your responses to the recommendations made in the "Preliminary Draft Existing Conditions Report." Your letter will be included as an appendix in the final version of that report along with this letter (and accompanying memorandum). During the coming month, the members of the TAC will also receive a detailed memorandum written by CTPS, at the request of the Massachusetts Department of Public Works. This memorandum explains specific problems that were identified and addressed concerning the portion of Highland Avenue between the Route 128 interchange and the Charles River.

We think it is important to reiterate why an existing conditions report was developed in the first place. During the course of our data collection and analysis, it became apparent that opportunities existed for making immediate improvements to traffic operations within the corridor. It was also apparent to us that the rapid commercial development now underway could foreclose long-term opportunities for improvement, if immediate steps were not taken to preserve the land necessary to accomplish these improvements. That is, the existing conditions report was designed to provide a means of:

- o Pointing out opportunities for making significant physical improvements of a relative short-term, inexpensive nature which are compatible with more long-term, capital intensive improvements that will also be necessary. Opportunities which fall into this category include signalization of unsignalized intersections, geometric upgrades, restriping of existing pavement and minor intersection widenings.
- o Also pointing out opportunities for protecting needed right-of-way now before the opportunity for acquisition of that right-of-way is lost. An example would be the reservation of land for a connection between Third and Fourth Avenues within the New England Industrial Center.

April 7, 1986

Your letter specifically notes the omission of the "Frontage Road" from the recommendations contained in this report. This is true only because of its long-term nature. This fact was not made clear in the draft of the report.

Due to the length of our responses, we have chosen to package our responses in the form of the attached memorandum. Each comment has been addressed in detail.

Again, we thank you for your comments. We look forward to working with you in advocating implementation of short-term opportunities during the 1986 construction season. We feel a united front must be presented in order to enhance the possibility of receiving a quick response to corridor needs from the MDPW.

Very truly yours,



Lawrence H. Tittlemore

LHT:od:53204

Attachment

cc: Barry Canner, Newton
Roy LaMotte, Newton
Calvin Cook, Needham
Jack Marr, Needham
Richard Robinson, Needham
John Fox, N/N Chamber of Commerce
Lewis Branzburg, N/N Chamber of Commerce
Michael Meyer, MDPW
John Gaynor, MDPW
Robert Patneaude, MDPW
Allan McKinnon, EOTC
Robert Sloane, EOTC
Edward Bates, MAPC

MEMORANDUM

TO: The Highland Avenue-Needham Street Corridor Technical Advisory Committee April 3, 1986

FROM: Lawrence H. Tittlemore
William T. Steffens

RE: Response to Newton-Needham Chamber of Commerce Letter of February 3, 1985

This memorandum serves as the CTPS response to the Newton, Needham and Chamber of Commerce members of the Highland Avenue-Needham Street Technical Advisory Committee (TAC) letter dated February 3, 1986. That letter contains comments concerning the recommendations within the "Preliminary Draft Existing Conditions Report for the Highland Avenue-Needham Street Corridor Traffic Study.

In section A of the letter, several comments were made that were stated to be in agreement with certain of the report recommendations.

Comment A.1: "That the installation of traffic lights at the Oak/Christina and Winchester/Dedham/Needham Streets intersections should proceed."

CTPS Response: While we did recommend that signals be installed at the Oak Street/Christina Street intersection, we do not recommend that these improvements proceed as currently planned by the Massachusetts Department of Public Works (MDPW). We believe that an integral part of this improvement requires that the Christina Street center line be brought into alignment with that of Oak Street and that the Oak Street approach be striped to accommodate an exclusive right-turn lane and a shared left-turn/through lane. The current MDPW plans do not contain either of these features. Without these features the signalization will introduce more delay than is necessary on Needham Street and unsafe vehicle maneuvering will continue.

Comment A.2: "There is a need for coordinating the timing of the Oak/Christina light with the Second Avenue light."

CTPS Response: Although we generally agree with the recommendation cited in A.2, we are not responsible for a recommendation proposing signal coordination between these intersections. The Manual on Uniform Traffic Control Devices (MUTCD) specifies that traffic control signals within 1/2 mile of one another should be

operated in coordination. Oak Street and Second Avenue do fall within 1/2 mile of one another. As also stated in the MUTCD, "...coordination need not be maintained across boundaries between signal systems which operate on different time cycles." This is an important caveat since adjustments to signal operations to accommodate coordination schemes necessitate the establishment of a "priority intersection" because phasings and timings are seldom identical between any two intersections. Furthermore, we reserve the right to withhold such a recommendation pending a review of signal operations at each location.

Comment A.3: "That Needham Street be re-stripped for three lanes to allow for left-turn movements."

CTPS Response: For clarity, the recommendation states that the third (center) lane be striped as a continuous two-way, left-turn lane.

Comment A.4: "That the median strip at First Avenue NOT be removed in the short run."

CTPS Response: We concur.

Comment A.5: "That the 5 lane configuration on Highland Avenue allow for a third lane westbound (continuous) to allow for southbound turns onto Second Avenue."

CTPS Response: A five-lane section on Highland Avenue between Second Avenue and the Highland Avenue Bridge is not recommended for implementation under current traffic conditions. Not specifically stated is the need for maintaining the present cross-section to provide safe transition to the Highland Avenue Bridge which remains one lane in each direction. Our recommendation regarding the three-legged Highland Avenue/Second Avenue intersection proposes, for Highland Avenue, the maintenance of the existing two-lane eastbound approach and the addition of an exclusive left-turn lane to the two through lanes on the westbound approach. This exclusive left-turn lane is required to separate left turns from through traffic. For the Second Avenue approach to this intersection, we recommend restriping of the existing pavement to provide for two exclusive left-turn lanes and one exclusive right-turn lane.

In section B of the letter, modifications to the report recommendations were proposed.

Comment B.1: "That the suggested improvements for Third and Fourth Avenue intersections with Kendrick Street proceed with the lane markings. The concept of one-way streets is not feasible because they cannot be connected by extending B Street without a

major land taking. The possibility of lights at 4th and/or 3rd should be considered, also."

CTPS Response: The recommended improvements for these intersections depend heavily on the establishment of a one-way pair system, with signalization at Third Avenue, and depend less on lane striping. We fully understand that land acquisition would be necessary to connect Third Avenue and Fourth Avenue. It appears to us that such a connection could be accomplished using land that is presently unbuilt upon. The lane striping by itself would provide little aside from formalizing the existing pattern of use.

Comment B.2: "That the suggested left turn lane eastbound on Highland Avenue in the vicinity (sic) of Charles and Wexford Streets be limited to left turns only into Charles Street, because there [are] so many more businesses north of Highland Avenue. This change would be predicated on continuing Charles Street as a two-way street and making Wexford Street a "Do Not Enter" street from Highland Avenue and requiring all traffic leaving Wexford Street [to] be limited to right turn only toward Route 128. This essentially captures the same concept as you suggest for Third and Fourth Avenue and would allow some stacking in the left turn lane eastbound without impeding other traffic eastbound. It could be done as a "pilot" program and if found to be unworkable, it could be abandoned."

CTPS Response: For the segment of Highland Avenue between Second Avenue and Route 128, the recommendation is for the establishment of a five-lane cross-section with a continuous left-turn lane for westbound, not eastbound, traffic. We do not agree that left turns should continue to be allowed from eastbound Highland Avenue into either Wexford Street or Charles Street. It is these very turns which severely disrupt traffic operations at the Second Avenue intersection today.

The suggested modification to the Wexford/ Charles Street operation, (i.e., forcing all left turns to and from Wexford Street onto Charles Street), is of limited technical value and could prove counter-productive, if implemented. The extreme proximity of Charles Street to the Highland Avenue/Second Avenue signalized intersection would make left turns from the commercial area north of Highland Avenue even more difficult. This would be due to the persistent blocking effect caused by stopped eastbound traffic on Highland Avenue during the Highland Avenue red phase. In addition, a major portion of the storage space (the distance between Charles Street and Wexford Street) currently used by westbound Highland Avenue traffic when left turns are being made to or from Wexford Street would be eliminated. The direct result of this loss of storage space would be lengthened traffic queues in two directions, with one queue stretching back toward the Highland Avenue Bridge and the other queue stretching into the New England Industrial Center. The suggested modification

could only be fully accomplished if the Charles Street approach to Highland Avenue was brought into alignment with the Second Avenue approach to Highland Avenue. Charles Street and Second Avenue operations could then be brought under the control of a single signal. This would involve major land-taking and building demolition.

We agree that this modification appears similar in concept to the recommendation made for improved operations at Third Avenue and Fourth Avenue. However, the physical conditions and traffic demands of the two locations are vastly different and require different improvement strategies. Furthermore, we would neither recommend nor expect the MDPW to experiment with a "pilot" project in this critical area.

Comment B.3: "We think further consideration needs to be given to the Floral Street/ramp connection recommendation (including considering making Floral Street two ways) to avoid trapping the apartment house residents."

CTPS Response: These considerations would be made in the design stages. There appears to be sufficient right-of-way available to provide the apartments with direct Centre Street access.

In section C of the letter, two areas of disagreement with the recommendations made in the report were noted.

Comment C.1: "In the short-run the jug handle solution is [not] practical because of the land-takings that would be necessary."

CTPS Response: It is true that this is not a project that could be accomplished in the short-term. It was included because of the immediate need to protect its potential right-of-way from the almost continuous development that is occurring along Highland Avenue.

Comment C.2: "We are also concerned about the suggested road to connect at the base of the hill with Second Avenue because it is too close to the intersection. Traffic would block Second Avenue southbound in trying to "get into line" on Second Avenue northbound. The very recent major and ongoing construction practically negates this possibility. Again the practicality involved in land-taking is not short-run..."

CTPS Response: We agree that land acquisition is required to successfully implement this action. This is the same right-of-way protection referred to in the C.1 response. The time required to acquire the necessary right-of-way is a matter for the Town of Needham to address. As to the potential for problems to occur at the intersection of the service road with Second Avenue, we do not agree that problems of any magnitude would occur as northbound traffic demand along Second Avenue peaks when

southbound demand is low. If necessary, the service road could be signal controlled at Second Avenue in coordination with the Highland Avenue/Second Avenue signal.

With respect to the effect of recent construction work in the immediate area of the proposed right-of-way, it is presently unclear if there is sufficient space remaining for construction of the road. Until it is confirmed that the necessary right-of-way no longer exists, this recommendation should not be dismissed out-of-hand. One necessary element for the successful improvement of traffic conditions on Highland Avenue, especially in the area of Second Avenue, Charles Street, Wexford Street, and the intervening block face, is the elimination of eastbound Highland Avenue left turns. The "jug-handle" aspect of the service road between First and Second avenues would permit the conversion of these left turns into right turns made from the westbound Highland Avenue traffic stream and eliminate the present disruptive effects caused by this traffic.

Comment C.2 (cont'd): "...We do not agree that the bridge may not become, if it is not now, a bottleneck."

CTPS Response: The examination of bridge capacity presented in the report offers a comparison of available capacity and peak hour demand. As indicated in the report, the bridge offers a higher level of service than does the Second Avenue/Highland Avenue intersection to its west and the Oak Street/Christina Street/Needham Street intersection to its east. The conclusion drawn from this finding is that unless and until one or the other intersection is upgraded to a capacity level above that of the bridge, the bridge will never act as a "bottleneck". If, at some future time, intersection improvements are completed at either intersection which raise the capacity above that of the bridge and travel also increases above the present bridge capacity, the bridge could act as a constraint to vehicle flow. No intersection capacity improvement of this magnitude is currently contemplated.

In section D of the letter, two additional recommendations are suggested.

Comment D.1: "That the restriction [on] right-turn-on red be removed at Second Avenue-Highland Avenue, thus creating a "release" in northbound Second Avenue backups."

CTPS Response: We agree that consideration should be given to the removal of the right-turn-on-red restriction on northbound traffic at the Second Avenue approach to Highland Avenue. We do feel, however, due to a low volume of right turns, that this action would have only a minor positive effect on traffic flow. The negative aspect of this action would be to intensify an already difficult situation for pedestrian movement. Keep in mind, it was either a safety consideration or a request from

Needham officials that led to the imposition of the turn restriction in the first place. We again reiterate our recommendation to restripe the Second Avenue approach to Highland Avenue with two exclusive left-turn lanes and one exclusive right-turn lane.

Comment D.2: "That the entire program keep in mind that the impending opening of the Hillside Office building and the proposed opening of the Sheraton Hotel next Fall will have a substantial impact on area traffic and consideration be given to [a] method of evaluating this impact."

CTPS Response: The traffic impact of these developments, together with all other foreseeable corridor growth, has been considered in the study of future conditions.

LHT:WTS:dap



The Commonwealth of Massachusetts
Executive Office of Transportation & Construction
Office of the Secretary

10 Park Plaza, Room 3510

Boston, MA 02116-3969

Telephone 973-7000

Michael S. Dukakis

Governor

Frederick P. Salucci

Secretary

and

M.B.T.A. Chairman

April 24, 1986

The Honorable Susan D. Schur
House of Representatives
State House, Rm. 277
Boston, MA 02133

Dear Susan:

Thank you for your letter of April 7th informing me of the concern of the Newton-Needham Chamber of Commerce in regard to progress on the Highland Avenue/Needham Street Corridor Traffic Study. I have attached copies of recent correspondence between the Chamber, acting as the spokesperson for local interests, and the Central Transportation Planning Staff (CTPS). As you know CTPS is now completing a detailed analysis of the corridor.

I would like to outline the major positive steps from that study effort. The Massachusetts Department of Public Works (MDPW) is currently completing plans to signalize the intersection of Needham Street with Oak/Christina streets and the intersection of Winchester Street with Needham/Dedham streets. The MDPW now anticipates the completion of these two installations during the present construction season. The MDPW has also awarded a contract to the consulting firm of Sverdrup & Parcel to undertake the environmental work associated with the Route 128 "Add-a-Lane" project. As a direct result of the CTPS analysis, an assessment of the feasibility of providing additional access to the New England Industrial Center from Route 128 will be included in that study.

Admittedly, the upgrading of the highway infrastructure has not kept pace with the overwhelming development in the entire Route 128 corridor. We view this phenomenon as a success story as well as the greatest challenge facing transportation planning professionals in the Commonwealth over the next decade.

Susan D. Schur

(2)

If you have any additional questions, or if I can be of any further assistance please feel free to contact me.

Sincerely,

Frederick P. Salvucci
Secretary of Transportation

FPS/RHP/dap

June 2, 1986

Mr. Michael Meyer
Director
BTP&D
10 Park Plaza
Boston, MA 02116

Attention: Robert Patneaude

Dear Mike:

Here is an analysis summary of signal operations at the Oak Street/Christina Street intersection on Needham Street using the AM and PM peak hour counts provided by Edwards and Kelcey. Heavy vehicle and peak hour factors were not directly provided so CTPS truck percentages and a peak hour factor of 0.9 were used throughout to lessen response time.

Two separate phasing schemes were evaluated in accordance with the requirements of the geometric configurations presently under consideration. As was discussed on May 13th, if the center line of Christina Street is not brought into direct alignment with that of Oak Street, a three-phase operation would be necessary to protect all Oak Street and Christina Street movements. With alignment, however, a simple two-phase operation would be possible.

The analysis results can be summarized as follows:

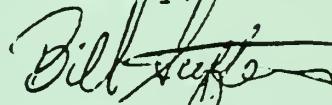
Peak Hour Level of Service Analysis
Oak Street/Christina Street at Needham Street

	<u>AM</u>	<u>PM</u>
Offset - Split Phase	D	F
Aligned - Two Phase	B	D

Detailed work sheets of the 1985 H.C.M. Chapter 9 signalized intersection analysis performed are attached.

Should you need any further information or have any further questions please contact me at 973-7107.

Sincerely,



William T. Steffens

WTS:od
Attachment

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS

Oak St./Christina St. offset. Split phase operation.

Edwards & Kelcev AM

date:05-29

time:15:09:52

LAST DATA SET NAMES LOADED OR SAVED

VOLUME=e&kam

GEOMETRICS=e&k

SIGNAL=split

LOCATED IN CBD:n

VOLUME & GEOMETRICS

VOLUMES				# OF LANES			LANE WIDTH			CURB TO
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	CURB
EB	74	919	93	1	1	0	11	14	0	0
WB	34	612	76	1	1	0	11	14	0	0
NB	37	55	22	0	1	0	0	12	0	0
SB	104	31	103	1	1	0	12	12	0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK		PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS BUT	MIN TIME TYPE
EB	0.0%	3.9%		0	0	.900	0	7.0 3
WB	0.0%	5.5%		0	0	.900	0	7.0 3
NB	0.0%	1.7%		0	0	.900	0	7.0 3
SB	0.0%	4.5%		0	0	.900	0	7.0 3

PHASINGS

EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*	*	*	*										83.6	5	A
2								*	*	*						11.8	5	A
3												*	*	*		9.6	5	A

CYCLE= 120.0

VOLUME ADJUSTMENT WORKSHEET

PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV%	THV%	RTV%	PHF	LTR	THR	RTR
EB	74	919	93	.900	82	1021	103
WB	34	612	76	.900	38	680	84
NB	37	55	22	.900	41	61	24
SB	104	31	103	.900	116	34	114

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Flt	Prt
EB	LT	82	1	1.00	82	1.00	0.00
EB	TH-RT	1124	1	1.00	1124	0.00	0.09
WB	LT	38	1	1.00	38	1.00	0.00
WB	TH-RT	764	1	1.00	764	0.00	0.11
NB	LT-TH-RT	127	1	1.00	127	0.32	0.19
SB	LT	116	1	1.00	116	1.00	0.00
SB	TH-RT	149	1	1.00	149	0.00	0.77

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN

OPPOSING APPROACH

BEING OPPOSED	VOLUMES			% IN PHASE WITH LEFT			# LANES		OPPOSING VOLUME
	LT	TH	RT	LT	TH	RT	LT	TH	
EASTBOUND	38	680	84	100	100	100	1	1	764
WESTBOUND	82	1021	103	100	100	100	1	1	1124
NORTHBOUND	116	34	114	0	0	0	1	1	0
SOUTHBOUND	41	61	24	0	0	0	0	1	0

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	1	0.957	0.981	1.000	1.000	1.000	1.000	0.288	481
EB	TH-RT	1800	1	1.067	0.981	1.000	1.000	1.000	1.000	0.888	1471

EB	TH-RT	1800	1	1.000	0.978	1.000	1.000	1.000	1.000	0.874	1.000	1402
NB	LT-TH-RT	1800	1	1.000	0.991	1.000	1.000	1.000	1.000	0.874	0.856	1335
SB	LT	1800	1	1.000	0.978	1.000	1.000	1.000	1.000	1.000	0.850	1497
SB	TH-RT	1800	1	1.000	0.978	1.000	1.000	1.000	1.000	0.796	1.000	1402

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
EB	120	84	1	82	1124	82	1.00	1	764	0.00
WB	120	84	1	38	764	38	1.00	1	1124	0.00

CALCULATIONS

DIR	Soa	Yo	Gu	Fs	P1	Gq	Pt	Gf	E1	Fm	Flt
EB	1800	0.425	56.758	0.397	1.000	26.858	0.000	0.000	2.832	0.288	0.288
WB	1800	0.625	23.057	0.172	1.000	60.559	0.000	0.000	6.532	0.090	0.090

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	82	491	0.17	0.70	342	0.24	
EB	TH-RT	1124	1671	0.67	0.70	1165	0.97	*
WB	LT	38	153	0.25	0.70	106	0.36	
WB	TH-RT	764	1654	0.46	0.70	1153	0.66	
NB	LT-TH-RT	127	1335	0.09	0.10	131	0.97	*
SB	LT	116	1497	0.08	0.08	120	0.97	*
SB	TH-RT	149	1402	0.11	0.08	112	1.33	

CYCLE=120.0 LOST=15.0 SUM V/S CRIT= 0.84 TOTAL V/C= 0.97

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg D	95% D
EB	LT	0.24	0.70	120	5.04	342	0.07	1.00	5.11	B	0.8	1
EB	TH-RT	0.97	0.70	120	12.81	1165	13.64	0.85	22.65	C	12.2	22
WB	LT	0.36	0.70	120	5.57	106	0.88	1.00	6.45	B	0.4	1
WB	TH-RT	0.66	0.70	120	7.79	1153	1.02	0.85	7.49	B	7.7	6
NB	LT-TH-RT	0.97	0.10	120	40.97	131	50.08	0.85	77.39	F	4.6	9
SB	LT	0.97	0.08	120	41.83	120	52.66	1.00	94.49	F	4.8	10
SB	TH-RT	1.33	0.08	120	43.19	112	266.48	0.85	263.22	F	13.2	34

DIR Delay LOS

EB 21.46 C
WB 7.44 B
NB 77.39 F
SB 189.49 F

INTERSECTION DELAY = 38.24 INTERSECTION LOS=D
THE EXISTING TIMING IS OPTIMAL

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
Oak St./Christina St. aligned. Proposed Timing

Edwards & Kelcey AM

date:05-29 time:14:50:23

LAST DATA SET NAMES LOADED OR SAVED

VOLUME=e&kam GEOMETRICS=e&k SIGNAL=e&k

LOCATED IN CBD:n

VOLUME & GEOMETRICS

VOLUMES				# OF LANES			LANE WIDTH			CURB TO
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	CURB
EB	74	919	93	1	1	0	11	14	0	0
WB	34	612	76	1	1	0	11	14	0	0
NB	37	55	22	0	1	0	0	12	0	0
SB	104	31	103	1	1	0	12	12	0	0

TRAFFIC & ROADWAY CONDITIONS

				ADJ PARK		PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME TYPE
EB	0.0%	3.9%		0	0	.900	0		7.0 3
WB	0.0%	5.5%		0	0	.900	0		7.0 3
NB	0.0%	1.7%		0	0	.900	0		7.0 3
SB	0.0%	4.5%		0	0	.900	0		7.0 3

PHASINGS

EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*	*	*	*										60.0	5	A
2								*	*	*		*	*	*		16.0	5	A

CYCLE= 86.0

VOLUME ADJUSTMENT WORKSHEET

PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV%	THV%	RTV%	PHF	LTR	THR	RTR
EB	74	919	93	.900	82	1021	103
WB	34	612	76	.900	38	680	84
NB	37	55	22	.900	41	61	24
SB	104	31	103	.900	116	34	114

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN	GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT		82	1	1.00	82	1.00	0.00
EB	TH-RT		1124	1	1.00	1124	0.00	0.09
WB	LT		38	1	1.00	38	1.00	0.00
WB	TH-RT		764	1	1.00	764	0.00	0.11
NB	LT-TH-RT		127	1	1.00	127	0.32	0.19
SB	LT		116	1	1.00	116	1.00	0.00
SB	TH-RT		149	1	1.00	149	0.00	0.77

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN		OPPOSING APPROACH			# LANES		OPPOSING
BEING OPPOSED	VOLUMES	% IN PHASE WITH LEFT			LT	TH	VOLUME
	LT	TH	RT	LT	TH	RT	
EASTBOUND	38	680	84	100	100	100	764
WESTBOUND	82	1021	103	100	100	100	1124
NORTHBOUND	116	34	114	100	100	100	149
SOUTHBOUND	41	61	24	100	100	100	86

SATURATION FLOW ADJUSTMENT WORKSHEET

EB		1800	1	1.067	0.981	1.000	1.000	1.000	1.000	1.000	0.109	524
EB	TH-RT	1800	1	1.067	0.981	1.000	1.000	1.000	1.000	0.838	1.000	1671
WB	LT	1800	1	0.967	0.973	1.000	1.000	1.000	1.000	1.000	0.109	185
WB	TH-RT	1800	1	1.067	0.973	1.000	1.000	1.000	1.000	0.885	1.000	1654
NB	LT-TH-RT	1800	1	1.000	0.991	1.000	1.000	1.000	1.000	0.874	0.880	1373
SB	LT	1800	1	1.000	0.978	1.000	1.000	1.000	1.000	1.000	0.821	1445
SB	TH-RT	1800	1	1.000	0.978	1.000	1.000	1.000	1.000	0.796	1.000	1402

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT
INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Flt	No	Vo	Flto
EB	86	60	1	82	1124	82	1.00	1	764	0.00
WB	86	60	1	38	764	38	1.00	1	1124	0.00
NB	86	16	1	127	86	41	0.32	1	149	0.00
SB	86	16	1	116	149	116	1.00	1	86	0.00

CALCULATIONS

DIR	Sec	Yo	Gv	Fs	Pl	Gq	Ft	Gf	E1	Fm	Flt
EB	1800	0.425	40.807	0.397	1.000	19.193	0.000	0.000	2.832	0.307	0.307
WB	1800	0.625	16.724	0.172	1.000	43.276	0.000	0.000	6.532	0.109	0.109
NB	1800	0.083	9.688	0.782	0.325	6.312	0.675	2.956	1.439	0.880	0.880
SB	1800	0.048	12.507	0.822	1.000	3.493	0.000	0.000	1.369	0.821	0.821

CAPACITY ANALYSIS WORKSHEET

DIR	LN	GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT		82	524	0.16	0.70	365	0.23	
EB	TH-RT		1124	1671	0.67	0.70	1166	0.96	*
WB	LT		38	185	0.20	0.70	129	0.29	
WB	TH-RT		764	1654	0.46	0.70	1154	0.66	
NB	LT-TH-RT		127	1373	0.09	0.19	255	0.50	
SB	LT		116	1445	0.08	0.19	269	0.43	
SB	TH-RT		149	1402	0.11	0.19	261	0.57	*

CYCLE= 86.0 LOST=10.0 SUM V/S CRIT= 0.78 TOTAL V/C= 0.88

LEVEL OF SERVICE WORKSHEET

DIR	LN	GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT		0.23	0.70	86	3.54	365	0.06	1.00	3.60	A	0.6	1
EB	TH-RT		0.96	0.70	86	9.13	1166	13.64	0.85	19.36	C	10.1	19
WB	LT		0.29	0.70	86	3.75	129	0.37	1.00	4.12	A	0.3	1
WB	TH-RT		0.66	0.70	86	5.55	1154	1.01	0.85	5.58	B	5.5	4
NB	LT-TH-RT		0.50	0.19	86	23.85	255	1.27	0.85	21.36	C	2.5	3
SB	LT		0.43	0.19	86	23.53	269	0.70	1.00	24.24	C	2.2	3
SB	TH-RT		0.57	0.19	86	24.22	261	2.20	0.85	22.46	C	2.9	4

DIR Delay LOS

EB 18.28 C
WB 5.51 B
NB 21.36 C
SB 23.24 C

INTERSECTION DELAY = 14.72 INTERSECTION LOS=B

optimal cycle length 86.0

suggested timing phase 1 is 65.6 secs green, 5.0 secs yellow + red clear
suggested timing phase 2 is 10.4 secs green, 5.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS

Oak St./Christina St. offset. Split phase operation.

Edwards & Kelcey PM

date:05-29

time:15:31:50

LAST DATA SET NAMES LOADED OR SAVED

VOLUME=e&kom

GEOMETRICS=e&k

SIGNAL=split

LOCATED IN CBD:n

VOLUME & GEOMETRICS

DIR	VOLUMES			# OF LANES			LANE WIDTH			CURB TO
	LT	TH	RT	LT	TH	RT	LT	TH	RT	CURB
EB	101	848	47	1	1	0	11	14	0	0
WB	26	958	200	1	1	0	11	14	0	0
NB	32	40	64	0	1	0	0	12	0	0
SB	112	58	119	1	1	0	12	12	0	0

TRAFFIC & ROADWAY CONDITIONS

DIR	GRADE	%HV	ADJ PARK		BUSES	PEDESTRIANS		ARR
			Y/N	MOVES		PHF	CROSS BUT MIN	
EB	0.0%	2.3%		0	0	.900	0	7.0
WB	0.0%	2.5%		0	0	.900	0	7.0
NB	0.0%	1.0%		0	0	.900	0	7.0
SB	0.0%	1.2%		0	0	.900	0	7.0

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*		*	*	*										90.0	5	A
2									*	*	*						8.8	5	A
3													*	*	*		6.2	5	A

CYCLE= 120.0

VOLUME ADJUSTMENT WORKSHEET

PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LT	TH	RT	PHF	LTFR	THFR	RTFR
EB	101	848	47	.900	112	942	52
WB	26	958	200	.900	29	1064	222
NB	32	40	64	.900	36	44	71
SB	112	58	119	.900	124	64	132

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	F1t	Frt
EB	LT	112	1	1.00	112	1.00	0.00
EB	TH-RT	994	1	1.00	994	0.00	0.05
WB	LT	29	1	1.00	29	1.00	0.00
WB	TH-RT	1287	1	1.00	1287	0.00	0.17
NB	LT-TH-RT	151	1	1.00	151	0.24	0.47
SB	LT	124	1	1.00	124	1.00	0.00
SB	TH-RT	197	1	1.00	197	0.00	0.67

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN

OPPOSING APPROACH

BEING OPPOSED	VOLUMES			% IN PHASE WITH LEFT			# LANES		OPPOSING VOLUME
	LT	TH	RT	LT	TH	RT	LT	TH	
EASTBOUND	29	1064	222	100	100	100	1	1	1287
WESTBOUND	112	942	52	100	100	100	1	1	994
NORTHBOUND	124	64	132	0	0	0	1	1	0
SOUTHBOUND	36	44	71	0	0	0	0	1	0

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	-F1t	s
EB	LT	1800	1	0.967	0.989	1.000	1.000	1.000	1.000	0.055	94
EB	TH-RT	1800	1	1.067	0.989	1.000	1.000	1.000	0.897	1.000	1695
WB	LT	1800	1	0.967	0.958	1.000	1.000	1.000	1.000	0.177	701

DIR	LN	GROUP	1800	1	1.000	0.994	1.000	1.000	1.000	1.000	0.838	0.968	1301
EB	LT		1800	1	1.000	0.994	1.000	1.000	1.000	1.000	1.000	0.850	1521
SB	TH-RT		1800	1	1.000	0.994	1.000	1.000	1.000	1.000	0.809	1.000	1448

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Flt	No	Vo	Flto
EB	120	90	1	112	994	112	1.00	1	1287	0.00
WB	120	90	1	29	1287	29	1.00	1	994	0.00

CALCULATIONS

DIR	So	Yo	Gu	Fs	F1	Gq	Pt	Gf	E1	Fm	Flt
EB	1800	0.715	14.807	0.071	1.000	75.194	0.000	0.000	15.882	0.055	0.055
WB	1800	0.552	52.967	0.253	1.000	37.034	0.000	0.000	4.438	0.177	0.177

CAPACITY ANALYSIS WORKSHEET

DIR	LN	GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT		112	94	1.19	0.75	71	1.59	*
EB	TH-RT		994	1695	0.59	0.75	1271	0.78	
WB	LT		29	304	0.09	0.75	228	0.13	
WB	TH-RT		1287	1662	0.77	0.75	1247	1.03	
NB	LT-TH-RT		151	1301	0.12	0.07	95	1.58	*
SB	LT		124	1521	0.08	0.05	79	1.58	*
SB	TH-RT		197	1448	0.14	0.05	75	2.63	

CYCLE=120.0 LOST=15.0 SUM V/S CRIT= 1.39 TOTAL V/C= 1.59

LEVEL OF SERVICE WORKSHEET

DIR	LN	GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT		1.59	0.75	120	2849.92	71	621.57	1.00	3471.48	F	108.7	325
EB	TH-RT		0.78	0.75	120	6.90	1271	2.28	0.85	7.80	B	8.3	7
WB	LT		0.13	0.75	120	3.15	228	0.01	1.00	3.16	A	0.2	1
WB	TH-RT		1.03	0.75	120	12.61	1247	27.88	0.85	34.42	D	17.7	38
NB	LT-TH-RT		1.58	0.07	120	44.30	95	591.63	0.85	540.54	F	25.0	69
SB	LT		1.58	0.05	120	44.67	79	607.13	1.00	651.80	F	24.5	68
SB	TH-RT		2.63	0.05	120	47.46	75	4094.37	0.85	3520.55	F	195.4	577

DIR Delay LOS

EB 359.04 F

WB 33.73 D

NB 540.54 F

SB 2408.78 F

INTERSECTION DELAY =448.06 INTERSECTION LOS=F

optimal cycle length 120.0

suggested timing phase 1 is	90.0 secs green,	5.0 secs yellow + red clear
suggested timing phase 2 is	8.8 secs green,	5.0 secs yellow + red clear
suggested timing phase 3 is	6.2 secs green,	5.0 secs yellow + red clear

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS

Oak St./Christina St. aligned Proposed Timing

Edwards & Kelcey PM Timings Optimized

date:05-29 time:14:22:21

LAST DATA SET NAMES LOADED OR SAVED

VOLUME=e&kpm GEOMETRICS=e&k SIGNAL=e&k

LOCATED IN CBD:n

VOLUME & GEOMETRICS

VOLUMES				# OF LANES			LANE WIDTH			CURB TO
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	CURB
EB	101	848	47	1	1	0	11	14	0	0
WB	26	958	200	1	1	0	11	14	0	0
NB	32	40	64	0	1	0	0	12	0	0
SB	112	58	119	0	2	0	0	12	0	0

TRAFFIC & ROADWAY CONDITIONS

ADJ PARK				PEDESTRIANS				ARR
DIR	GRADE	%HV	Y/N MOVES	BUSES	PHF	CROSS	BUT MIN	TIME TYPE
EB	0.0%	2.3%	0	0	.900	0	7.0	3
WB	0.0%	2.5%	0	0	.900	0	7.0	3
NB	0.0%	1.0%	0	0	.900	0	7.0	3
SB	0.0%	1.2%	0	0	.900	0	7.0	3

PHASINGS

EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*	*	*	*										66.2	5	A
2								*	*	*		*	*	*		9.8	5	A

CYCLE= 86.0

VOLUME ADJUSTMENT WORKSHEET

PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV%	THV%	RTV%	PHF	LTR	THR	RTTR
EB	101	848	47	.900	112	942	52
WB	26	958	200	.900	29	1064	222
NB	32	40	64	.900	36	44	71
SB	112	58	119	.900	124	64	132

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN	GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT		112	1	1.00	112	1.00	0.00
EB	TH-RT		994	1	1.00	994	0.00	0.05
WB	LT		29	1	1.00	29	1.00	0.00
WB	TH-RT		1287	1	1.00	1287	0.00	0.17
NB	LT-TH-RT		151	1	1.00	151	0.24	0.47
SB	LT-TH-RT		321	2	1.05	337	0.39	0.41

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN BEING OPPOSED	OPPOSING APPROACH								
	VOLUMES			% IN PHASE WITH LEFT			# LANES		OPPOSING VOLUME
	LT	TH	RT	LT	TH	RT	LT	TH	
EASTBOUND	29	1064	222	100	100	100	1	1	1287
WESTBOUND	112	942	52	100	100	100	1	1	994
NORTHBOUND	124	64	132	100	100	100	0	2	321
SOUTHBOUND	36	44	71	100	100	100	0	1	116

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN	GROUP	IDEAL N	Fwid	Fhy	Fpr	Fpark	Fbus	Fbiker	Frt	Flt	
-----	----	-------	---------	------	-----	-----	-------	------	--------	-----	-----	--

EB	LT	1800	1	1.067	0.988	1.000	1.000	1.000	1.000	1.000	1.000	1287
WB	LT	1800	1	0.967	0.988	1.000	1.000	1.000	1.000	1.000	0.203	148
WB	TH-RT	1800	1	1.067	0.988	1.000	1.000	1.000	1.000	0.877	1.000	1662
NB	LT-TH-RT	1800	1	1.000	0.995	1.000	1.000	1.000	1.000	0.836	0.802	1201
SB	LT-TH-RT	1800	2	1.000	0.994	1.000	1.000	1.000	1.000	1.000	0.880	3150

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT

INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
EB	86	66	1	112	994	112	1.00	1	1287	0.00
WB	86	66	1	29	1287	29	1.00	1	994	0.00
NB	86	10	1	151	116	36	0.24	2	321	0.39
SB	86	10	2	321	321	124	0.39	1	116	0.00

CALCULATIONS

DIR	So	Yo	Gu	Fs	Pl	Gq	Pt	Gf	E1	Fm	Flt
EB	1800	0.715	16.742	0.071	1.000	49.507	0.000	0.000	15.882	0.076	0.076
WB	1800	0.552	41.866	0.253	1.000	24.383	0.000	0.000	4.438	0.203	0.203
NB	3115	0.103	0.989	0.674	0.235	8.762	0.765	4.493	1.668	0.802	0.802
SB	1800	0.064	4.521	0.803	0.852	5.231	0.148	0.344	1.401	0.761	0.880

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	112	131	0.86	0.77	101	1.11	*
EB	TH-RT	994	1695	0.59	0.77	1306	0.76	
WB	LT	29	348	0.08	0.77	268	0.11	
WB	TH-RT	1287	1662	0.77	0.77	1281	1.00	
NB	LT-TH-RT	151	1201	0.13	0.11	136	1.11	*
SB	LT-TH-RT	337	3150	0.11	0.11	357	0.94	

CYCLE= 86.0 LOST=10.0 SUM V/S CRIT= 0.98 TOTAL V/C= 1.11

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT	1.11	0.77	86	11.90	101	115.85	1.00	127.75	F	4.3	13
EB	TH-RT	0.76	0.77	86	4.17	1306	1.89	0.85	5.15	B	5.5	5
WB	LT	0.11	0.77	86	1.88	268	0.01	1.00	1.89	A	0.2	1
WB	TH-RT	1.00	0.77	86	7.63	1281	20.40	0.85	23.83	C	12.0	26
NB	LT-TH-RT	1.11	0.11	86	29.39	136	103.63	0.85	113.07	F	6.3	15
SB	LT-TH-RT	0.94	0.11	86	28.77	357	24.21	0.85	45.03	E	7.4	13

DIR Delay LOS

EB 17.58 C

WB 23.34 C

NB 113.07 F

SB 45.03 E

INTERSECTION DELAY = 28.32 INTERSECTION LOS=D

THE EXISTING TIMING IS OPTIMAL

EDWARDS & KELCEY
Engineers and Consultants
286 Congress St.
BOSTON, MASSACHUSETTS 02210

Phone 542-4576

LETTER OF TRANSMITTAL

DATE	5-20-86	JOB NO.	
ATTENTION	L. GILMARTIN		
RE	Newton-Dick/Christina		

TO: MASS DEPT. OF PUBLIC WORKS
10 PARK PLAZA
BOSTON, MA - 02116.

GENTLEMEN:

WE ARE SENDING YOU ☐ Attached ☐ Under separate cover via _____ the following items:

☐ Shop drawings ☐ Prints ☐ Plans ☐ Samples ☐ Specifications

☐ Copy of letter ☐ Change order ☐ _____

COPIES	DATE	NO.	DESCRIPTION
1.		2.	Am & Pm Turning Movement Counts

THESE ARE TRANSMITTED as checked below:

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| <input type="checkbox"/> For approval | <input type="checkbox"/> Approved as submitted | <input type="checkbox"/> Resubmit _____ copies for approval |
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| <input type="checkbox"/> FOR BIDS DUE _____ 19____ <input type="checkbox"/> PRINTS RETURNED AFTER LOAN TO US | | |

REMARKS _____

COPY TO _____

SIGNED:

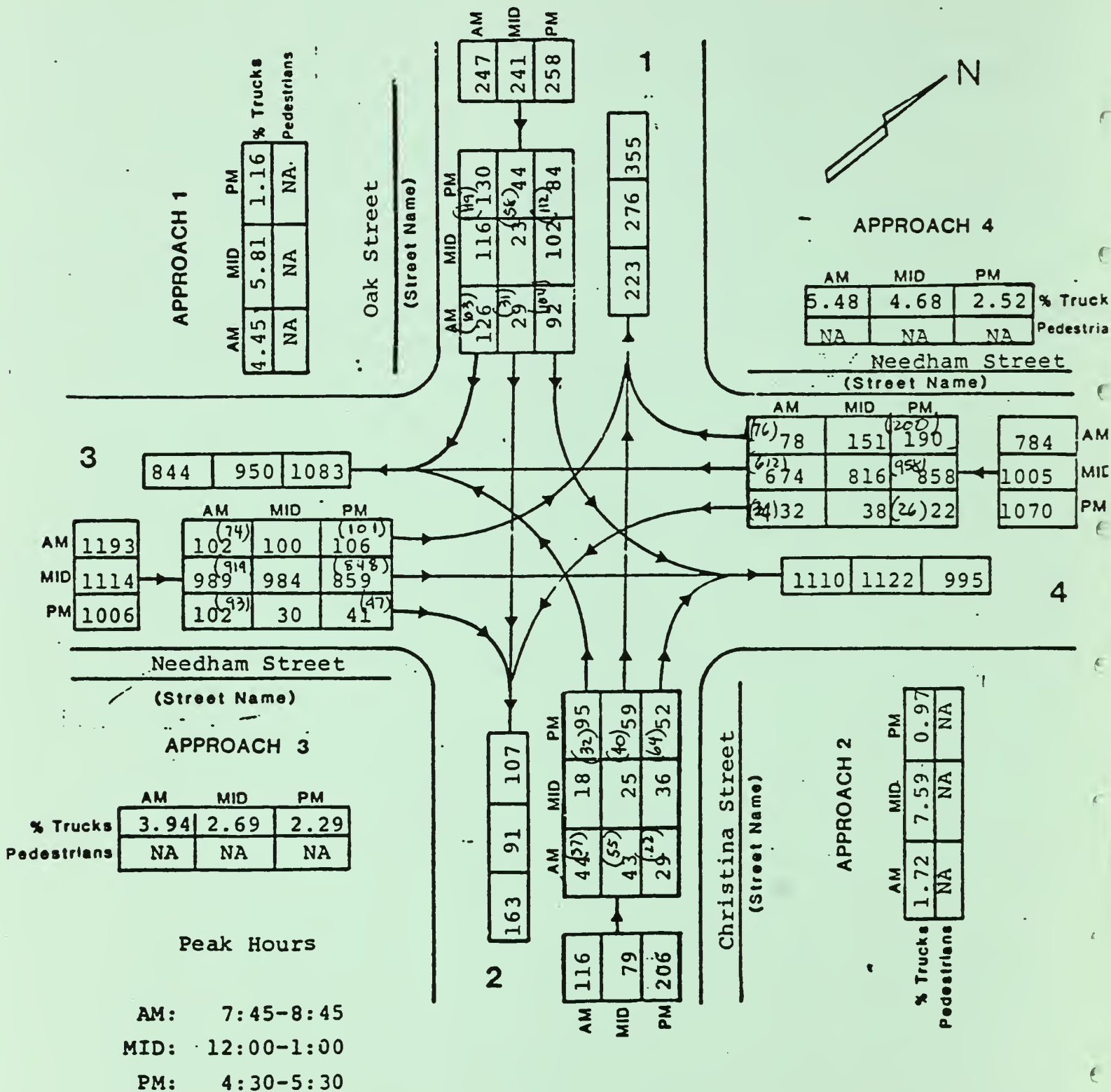
Rodney Emery

If enclosures are not as noted, kindly notify us at once.

SUMMARY OF VEHICLE MOVEMENTS

Intersection Needham Street @ Oak Street & Christina Street

Date 9/18/84 Day of Week Tuesday Weather Fair 60°F Community Newton



MEMORANDUM

TO: Highland Avenue/Needham Street
Corridor Traffic Engineering
Analysis Project Files

FROM: William T. Steffens

RE: Meeting for Discussion of Short-range
Improvement of Highland Avenue and
Needham Street

July 10, 1986

The following is a summary of the meeting held this morning with representatives of the Massachusetts Department of Public Works, Edwards and Kelcey and CTPS. Following a discussion of the analyses that had been completed to date, the attendees agreed that the following improvements should be implemented at the earliest possible time.

Needham Street/Dedham Street/Winchester Street Intersection

Improve as proposed in the Edwards and Kelcey design plans.

Needham Street/Oak Street/Christina Street Intersection

Signals should be installed and the intersection approaches should be striped as proposed in the Edwards and Kelcey design plans. The signal should be wired for three-phase operation although it would initially be in two-phase operation. This would allow a switch from a typical two-phase operation when necessary to protect all Oak Street and Christina Street movements during peak periods.

Needham Street

Needham Street from Christina Street east to Winchester Street should be re-striped as three lanes with the median lane operating as a continuous, two-way, left-turn lane.

Highland Avenue/Second Avenue Intersection

The Highland Avenue approach to this intersection should be improved to include two through traffic lanes and one exclusive left-turn lane.

These actions should be implemented concurrently to ensure that the problems present at each location do not continue to disrupt operations at adjacent locations and reduce the overall level of improvement possible.

July 10, 1986

It was also agreed that the signal and channelization improvements to be made at the Needham Street/Oak Street/Christina Street intersection are short-term in nature and that the land acquisition process should begin immediately to permit the alignment of Christina Street with Oak Street approximately five years hence.

It should also be noted that, although no mention was made of it at the meeting, the CTPS recommendation for improving the Highland Avenue/Second Avenue intersection as documented in the "existing conditions" report included re-striping of the Second Avenue approach as a double left-turn lane and a right-turn bay. This improvement can easily be made as part of the discussed improvements in that they can be implemented without land taking or geometric alteration.

Finally, CTPS agreed to provide the MDPW and Edwards and Kelcey with a final capacity analysis of the proposed improvements at the Needham Street at Oak Street and Christina Street intersection.

WTS:od

cc: Michael Meyer
Robert Shea
Robert Patneaude
Peter Kutrubes
Commissioner Digeronimo

Notes on Highland Avenue/Needham Street
Meeting July 15, 1986

In attendance were:

Ellen DiGeronimo	Associate Commissioner, MDPW
Robert Patneaude	Principal Civil Engineer, MDPW
Susan Schur	State Representative, Newton
Robert Shea	Traffic Engineer, MDPW
William Steffens	Principal Planner, CTPS
Lawrence Tittlemore	Manager Systems Projects, CTPS

Commissioner DiGeronimo opened the meeting noting that the study effort had provided the MDPW with several actions that would be ready to be advertised for bid by October, 1986. W. Steffens presented an overview of the Highland Avenue/Needham Street corridor and discussed existing land use and development potential. L. Tittlemore presented a description of the critical problems affecting corridor travel with the aid of a series of slides.

Four proposals which are jointly supported by the MDPW and CTPS were then presented for discussion.

- o Signalization, of Needham Street at Winchester Street/
Dedham Street Intersection. L. Tittlemore stated that plans for improving this location are anticipated to resolve the vehicle conflict problems present at the intersection and introduce gaps in the Route 9 directed traffic stream providing some relief in the operation of the Route 9 ramps.
- o Continuous, Two-way, Left-turn Lane along Needham Street R. Shea pointed out the crucial importance of enforcement by area safety officers in the initial stages following the start of two-way, left-turn lane operations. In addition, he noted the necessity of informational signing describing the operation of the two-way section and stated that use of the central lane for anything other than entering and turning in the initial stage or at any other time can result in serious hazards to drivers.
- o Signalization of Needham Street at Oak Street and Christina Street. Representative Schur noted the need for this project at the earliest possible date to improve area safety.
- o Channelization, of Highland Avenue and Second Avenue Intersection. W. Steffens indicated this project was needed to permit vehicles to better use available capacity. R. Shea noted that the project would need to be postponed to examine whether sufficient right-of-way existed to accommodate the number of lanes. Representative Schur stated that the progress of the three remaining projects should not be

interfered with by the slower progress of the fourth. Commissioner DiGeronimo agreed and reiterated that the project was not being cancelled, but postponed, to allow work on the other projects to continue toward completion by the earliest possible date. The MDPW will continue to work on the Highland Avenue/Second Avenue intersection as a short-range improvement project.

Representative Schur expressed her concern over the length of time it has taken CTPS to complete work on the Highland Avenue/Needham Street study. Commissioner DiGeronimo stated that the MDPW would attempt to minimize any further interference with the staff in completing the study work.

Ellen DiGeronimo, Associate Commissioner

July 16, 1986

Mr. Michael D. Meyer, Director
BTP&D
10 Park Plaza
Boston, MA 02116

Attention: Robert Patneaude

Dear Mike:

The Needham Street at Oak Street and Christina Street intersection has been reevaluated assuming signal installation without geometric change. In this analysis a two-phase, 90 second cycle was tested.

To correct for the effects of the Christina Street/Oak Street offset, adjustments were made in two worksheet entries. To reflect the additional vehicle maneuvering required to clear the intersection and the conflict between Oak Street and Christina Street left turns, saturation and opposing volume totals were changed.

The hourly saturation volumes for Oak Street and Christina Street were reduced by 10 percent as an indication of the through and left-turn maneuvering required between these streets. The southbound opposing volume total was also adjusted to include the left-turn volume from Christina Street conflicting with Oak Street movements under the present configuration.

As in the analysis done previously and transmitted by memo on June 2, 1986, traffic counts supplied by Edwards and Kelcey were used. P.M. peak hour conditions are the only examined as these are representative of the highest time-of-day demands. The attached sheets provide a detailed worksheet summary of the analysis results. As shown on the output sheet, phase timing was allocated so that critical movement V/C ratios are equivalent.

Under these assumptions an average intersection vehicle delay is estimated at approximately 39 seconds, indicating level of service D conditions. Needham Street should operate at an acceptable (C) level of service, although side street traffic on Oak Street and Christina Street is likely to experience extreme delay (service level F) conditions.

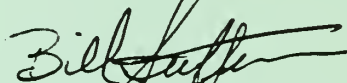
Michael D. Meyer, Director -2-

July 16, 1986

The analysis of split phase operations, (to be used when necessary for safety reasons), during periods of peak traffic loading is unchanged from the previous transmittal.

Should you need any further information or have any further questions, please contact me at 973-7107.

Sincerely,

A handwritten signature in dark ink, appearing to read "Bill Steffens", with a stylized flourish at the end.

William T. Steffens

WTS:dap

cc: Robert Shea
Peter Kutrubes
Robert Hartnett

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS
 Oak St./Christina St. offset with left turn conflicts Oak and Christina saturati
 on reduced 10%

Edwards & Kelcey PM
 date:07-11-1986 time:01:44:11
 LAST DATA SET NAMES LOADED OR SAVED
 VOLUME=e&kpm GEOMETRICS=e&k SIGNAL=e&k
 LOCATED IN CBD:n

VOLUME & GEOMETRICS

VOLUMES				# OF LANES			LANE WIDTH			CURB TO
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	CURB
EB	101	848	47	1	1	0	11	14	0	0
WB	26	958	200	1	1	0	11	14	0	0
NB	32	40	64	0	1	0	0	12	0	0
SB	112	58	119	0	2	0	0	12	0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK		PEDESTRIANS		ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS BUT MIN TIME TYPE
EB	0.0%	2.3%		0	0	.900	0 7.0 3
WB	0.0%	2.5%		0	0	.900	0 7.0 3
NB	0.0%	1.0%		0	0	.900	0 7.0 3
SB	0.0%	1.2%		0	0	.900	0 7.0 3

PHASINGS

EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
1	t	r	p	1	t	r	p	1	t	r	p	1	t	r	p			
1	*	*	*	*	*	*		*	*	*		*	*	*		69.0	5	A
2								*	*	*		*	*	*		11.0	5	A

CYCLE= 90.0

VOLUME ADJUSTMENT WORKSHEET

PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTR	THR	RTTR
EB	101	848	47	.900	112	942	52
WB	26	958	200	.900	29	1064	222
NB	32	40	64	.900	36	44	71
SB	112	58	119	.900	124	64	132

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN	GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT		112	1	1.00	112	1.00	0.00
EB	TH-RT		994	1	1.00	994	0.00	0.05
WB	LT		29	1	1.00	29	1.00	0.00
WB	TH-RT		1287	1	1.00	1287	0.00	0.17
NB	LT-TH-RT		151	1	1.00	151	0.24	0.47
SB	LT-TH-RT		321	2	1.05	337	0.39	0.41

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN OPPOSING APPROACH

BEING OPPOSED	VOLUMES			% IN PHASE WITH LEFT			# LANES		OPPOSING VOLUME
	LT	TH	RT	LT	TH	RT	LT	TH	
EASTBOUND	29	1064	222	100	100	100	1	1	1287
WESTBOUND	112	942	52	100	100	100	1	1	994
NORTHBOUND	124	64	132	100	100	100	0	2	321
SOUTHBOUND	36	44	71	100	100	100	0	1	116

SATURATION FLOW ADJUSTMENT WORKSHEET

EB	LT	1800	1	0.967	0.989	1.000	1.000	1.000	1.000	1.000	0.073	126
EB	TH-RT	1800	1	1.067	0.989	1.000	1.000	1.000	1.000	0.893	1.000	1695
WB	LT	1800	1	0.967	0.988	1.000	1.000	1.000	1.000	1.000	0.199	342
WB	TH-RT	1800	1	1.067	0.988	1.000	1.000	1.000	1.000	0.877	1.000	1662
NB	LT-TH-RT	1620	1	1.000	0.995	1.000	1.000	1.000	1.000	0.836	0.791	1067
SB	LT-TH-RT	1620	2	1.000	0.994	1.000	1.000	1.000	1.000	1.000	0.760	2449

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT
INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Flt	No	Vo	Flto
EB	90	69	1	112	994	112	1.00	1	1287	0.00
WB	90	69	1	29	1287	29	1.00	1	994	0.00
NB	90	11	1	151	116	36	0.24	2	321	0.39
SB	90	11	2	321	321	124	0.39	1	151	0.24

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
EB	1800	0.715	16.524	0.071	1.000	52.521	0.000	0.000	15.892	0.073	0.073
WB	1800	0.552	43.178	0.253	1.000	25.868	0.000	0.000	4.438	0.199	0.199
NB	3115	0.103	1.870	0.674	0.235	9.084	0.765	4.578	1.668	0.791	0.791
SB	1555	0.097	2.455	0.781	1.000	8.499	0.000	0.000	1.441	0.521	0.760

CAPACITY ANALYSIS WORKSHEET

DIR	LN	GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT		112	126	0.89	0.77	96	1.16	*
EB	TH-RT		994	1695	0.59	0.77	1300	0.76	
WB	LT		29	342	0.08	0.77	262	0.11	
WB	TH-RT		1287	1662	0.77	0.77	1275	1.01	
NB	LT-TH-RT		151	1067	0.14	0.12	130	1.16	*
SB	LT-TH-RT		337	2449	0.14	0.12	298	1.13	

CYCLE= 90.0 LOST=10.0 SUM V/S CRIT= 1.04 TOTAL V/C= 1.16

LEVEL OF SERVICE WORKSHEET

DIR	LN	GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg D	95% D
EB	LT		1.16	0.77	90	17.43	96	148.96	1.00	166.39	F	5.5	16
EB	TH-RT		0.76	0.77	90	4.49	1300	1.94	0.85	5.47	B	5.8	5
WB	LT		0.11	0.77	90	2.03	262	0.01	1.00	2.03	A	0.2	1
WB	TH-RT		1.01	0.77	90	8.20	1275	21.43	0.85	25.18	D	12.7	28
NB	LT-TH-RT		1.16	0.12	90	30.74	130	135.23	0.85	141.08	F	7.6	19
SB	LT-TH-RT		1.13	0.12	90	30.59	298	90.87	0.85	103.24	F	12.7	29

DIR Delay LOS

EB 21.78 C

WB 24.67 C

NB 141.08 F

SB 103.24 F

INTERSECTION DELAY = 38.72 INTERSECTION LOS=D

THE CYCLE LENGTH WITHIN THE BOUNDS OF 90 TO 90 SECONDS

WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 90 SECONDS

THE EXISTING TIMING IS OPTIMAL

[illegible]

1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 2653, 2654, 2655, 2656, 2657, 2658, 2659, 2660, 2661, 2662, 2663, 2664, 2665, 2666, 2667, 2668, 2669, 2670, 2671, 2672, 2673, 2674, 2675, 2676, 2677, 2678, 2679, 26

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